

Architectural Conservation and Historic Preservation
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Lecture - 31
Conservation of Historic Structures : Maintenance and Repair (Contd.)

We will continue with the maintenance and repair we have been talking about the substructure superstructure and foundation, strengthening of foundation, then we also have been talking about the different types of material of the masonry, we are talking about the stone, and we will continue with that. First we will talk about some of the examples of the maintenance and repair and conservation of the stone structure in India.

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The slide is titled "Conservation of stone masonry" and "The Sun Temple at Konarak". It discusses the material "Highly Ferruginous Khondalite stone" (garneti – ferrous sillimanite schist) and lists several weathering and decay factors. A photograph of the Sun Temple at Konarak is shown on the right. The slide also includes a reference to UNESCO (1979) and logos for IIT Kharagpur and NPTEL.

Conservation of stone masonry

Highly Ferruginous Khondalite stone
garneti – ferrous sillimanite schist

- Weathers into sandy rock with red and brown streaks and patches
- Sculptures eroded alkalis leached out – irregular surface
- Oxidation of ferrous into ferric iron – greenish colour to reddish stains
- Soluble salts carried by wind and deposited on the stone
- Accumulated water due to coastal rain seeping out through sculptures
- Interiors covered with moss and lichen
- Rusting of original iron dowels and cramps

The Sun Temple at Konarak



Ref: UNESCO (1979) .The Conservation of Cultural Property :Museums and Monuments XI. Belgium

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Let us talk about the sun temple of Konark is a world heritage sites, we have discussed that many times, and it is. Let us see what is the material it is made of, it is made of Khondalite stone, it is a highly ferruginous Khondalite stone. So, what it happen is that, it is a lot of (Refer Time: 01:01) within that it is a (Refer Time: 01:03) ferrous material. So, there content is that earth and that is actually one has to understand, to understand that what type of damages or decay what is happening there.

Now, if you just broadly see that what it has undergone is that the weathers into a sandy rock with red and brown streaks and patches. There weathering is very predominant factor, because that ferruginous material it sort of decays when it comes in contact with

the water. And the sculpture eroded and in as a process the alkalis leached out and which lead to the irregular surface; Oxidation of ferrous into the ferric iron, where the greenish colour to the reddish stains.

So, that is what happened, because of the chemical changes to happening, because of the composition of this particular type of stone, and the soluble salts which are carried by, so the location is very important, it is very close to the sea. Soluble salts carried between and deposited on the stone and that caused for the problem. And also because due to the accumulate water, due to the coastal rain seeping out through the structures and the sculptures and interiors covered with moss and lichens.

So, these are the broadly the types of problems which found in Konarak temple, and I am and also the dowels which are use the stones were there with some sort of an iron dowel solution that were corroded, because of noting into water, but the salinity of the water and which corroded and it is causes cracked to the stone.

So, these are the broadly, the major types of defects which were found in Konark stone. Now I must mention that I am using that reference which have given that it is 1979. So, I am sure that archaeological survey is continuously doing other measures or the preventive measure, repair work and they have improved and. So, one has to take help of them to understand what are the basically things, but I am following these reference, where some of the broad type of measures, which repair measures which are there an understanding.


(Refer Slide Time: 03:22)

The slide is titled "Conservation of stone masonry" and "The Sun Temple at Konarak". It is divided into two main sections. The left section, titled "Protective Measures", includes "Small-scale repairs" which involve "Clearance of vegetation, re-setting of loose stones, pointing and filling in the crevices". Below this text is a photograph of a stone structure, likely part of the Sun Temple at Konarak. The right section, titled "The Sun Temple at Konarak", lists several conservation measures: "Platform grouted with liquid cement mixed with sand and 'ironite' (inert water proofing material) through hundreds of drilled holes", "Terracing with fresh lime concrete mixed with cement and ironite", "Rusted iron cramps replaced with copper ones", "Chemical treatment by way of removal of moss and lichen, elimination of injurious salts by the application of paper-pulp and fungicidal treatment", and "Steps to prevent accumulation of stagnant water in the foundation and reversing the slopes wherever necessary". At the bottom left, there is a reference: "Ref: UNESCO (1979). The Conservation of Cultural Property Museums and Monuments XI. Belgium". The bottom of the slide features the IIT KHARAGPUR logo and the NPTEL ONLINE CERTIFICATION COURSES logo. A small video inset in the bottom right corner shows a person speaking.

Conservation of stone masonry

Protective Measures

Small-scale repairs
Clearance of vegetation, re-setting of loose stones, pointing and filling in the crevices



Ref: UNESCO (1979). The Conservation of Cultural Property Museums and Monuments XI. Belgium

The Sun Temple at Konarak

- Platform grouted with liquid cement mixed with sand and 'ironite' (inert water proofing material) through hundreds of drilled holes
- Terracing with fresh lime concrete mixed with cement and ironite
- Rusted iron cramps replaced with copper ones
- Chemical treatment by way of removal of moss and lichen, elimination of injurious salts by the application of paper-pulp and fungicidal treatment
- Steps to prevent accumulation of stagnant water in the foundation and reversing the slopes wherever necessary

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Now, what are the protective measures which happen in Konarak temple. One of them is a small scale repair, which included clearance of vegetation or resetting of the loose stones which came out pointing and filling of the crevices. These were being continuously done, this is a small scale repair and as you can see that some pointing also has been done there to keep.

It has not been reconstructed whatever there it was an Anastolisis process, but keeping the stones in that position and doing some repair work was very important of this particular type of stone. And then some of the other nations were also taken, the platform was crowded with liquid cement, grouting we have talked about when we talked about consolidation, the grouting with the liquid cement mixed with sand and ironite.

Ironite is an inert waterproofing material through hundreds of drilled holes through the surface, and so that to give a sort of a strength to the terracing with, because the tools there is no water accumulation the terracing was required. Terracing with fresh lime concrete mixed with cement and ironite and rusted iron cramps were replaced with the copper ones, and chemical treatment by way of removal of moss and lichen, elimination of injurious salts, which are accumulating and coming with the salt with the air, these injurious salts by application of paper pulp. We have already explained the paper pulp treatment and fungicidal treatment.

Broadly these are some of the measures which have been taken by A S I, and also two steps to prevent accumulation of the stagnant water in the foundation and reversing the slope wherever necessary. There of course, in case of Konarak there the major problem is that the structure which is still sealed and there is a stone inside, that is a major challenge which is happening, a major restoration method or is going on, but even at the moment I am not talking about that. I am just talking about the preventive measures, the maintenance care, the repair which has been done in a small scale or over the years, to keep that in the preservation state.

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Conservation of stone masonry

The Gol Gumbaz in Bijapur

Deterioration

- Falling off of salt infected plaster
- Rusty iron dowels weakening the brick core of the dome
- Cracks in the plaster

Protective Measures

- Grouting of cracks
- Dome exterior made watertight by special cement Gunite (1 part portland cement : 3.5 parts sand)
- Inner plaster stripped off followed by application of gunite shell of varying thickness
- New plaster matching the color of the existing dome
- Stainless hooks replaced rusted iron hooks and dowels

Ref: UNESCO (1979) .The Conservation of Cultural Property Museums and Monuments XI. Belgium

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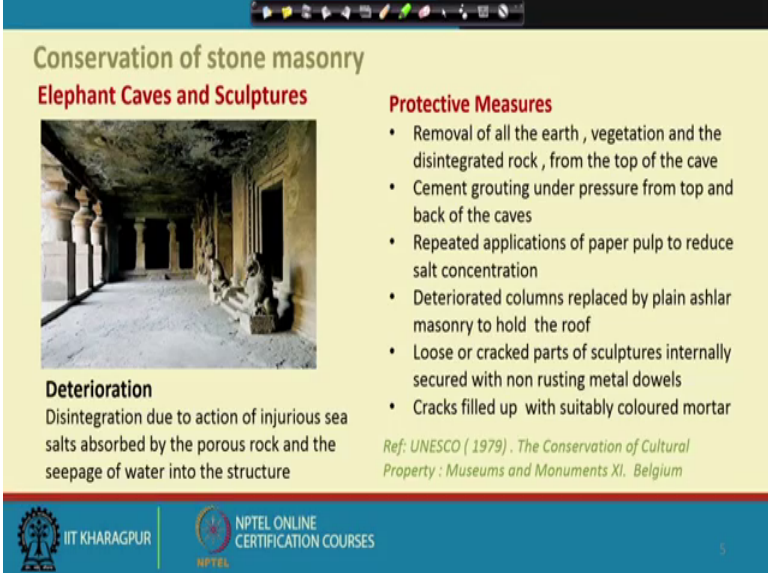
Let us talk about the Gol Gumbaz in Bijapur, it is also another very interesting structure known for a stone and the acoustic property of the dome the; Let us see what are the types of the deterioration which happen in Gol Gumbaz. And first of all falling of the salt infected plaster and the rusty iron dowels weakening the brick core of the dome, it is imaginary structure of brick and the cracks in the plaster which happened. So, let us see what are the protective measure which were taken in this case.

Now, this is basically is a machinery structure made of brick and plaster, and some stones which were there. Now it is a composite material structure. So, first of all the grouting of the cracks which happened, and the dome exterior was made watertight by special cement gunite, one part of Portland cement, 2 3.5 parts of sand, that composition is important and again the experts, who have been experienced in such astonishing

measures and maintenance measure the, can only say that what is required, and in a plaster was stripped off followed by application of the gunite shell of varying thickness, because it is a huge dome.


So, how the plaster will be relied that was also very important to understand and the new plaster matching the colour of the existing domes. This is how it was repaired and the stainless steel hook you see that, this iron is no longer, wherever there is an iron dowels or any iron joined any crams hooks and other thing, they are always replaced with the rust proof, either stainless steel or copper hooks I think. So, this is a very important part and these are the some of the measures which happen in Gol Gumbaz.

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Conservation of stone masonry

Elephant Caves and Sculptures



Deterioration
Disintegration due to action of injurious sea salts absorbed by the porous rock and the seepage of water into the structure

Protective Measures

- Removal of all the earth, vegetation and the disintegrated rock, from the top of the cave
- Cement grouting under pressure from top and back of the caves
- Repeated applications of paper pulp to reduce salt concentration
- Deteriorated columns replaced by plain ashlar masonry to hold the roof
- Loose or cracked parts of sculptures internally secured with non rusting metal dowels
- Cracks filled up with suitably coloured mortar

Ref: UNESCO (1979). The Conservation of Cultural Property: Museums and Monuments XI. Belgium

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Let us talk about another world heritage site which is the Elephanta Caves and sculptures within that the. Sorry there is a spelling mistake it is actually Elephanta Caves and this is rock cut caves which is there, and there is a lot of problems in that; Let us see the type of deterioration which happened there, it is disintegration due to action of injurious sea salt. So, you see the location something which is close to the sea, there are sometimes most of the time it is a fine Mahabalipuram Elephanta Caves schooner out; All of these a problem due to the salinity in the water and air.

So, disintegration due to action of injurious sea salts absorbed by the porous rock and the seepage of water into the structure so, the water is coming through the top of the structure and that was creating the problem. You can see the science of that the damage

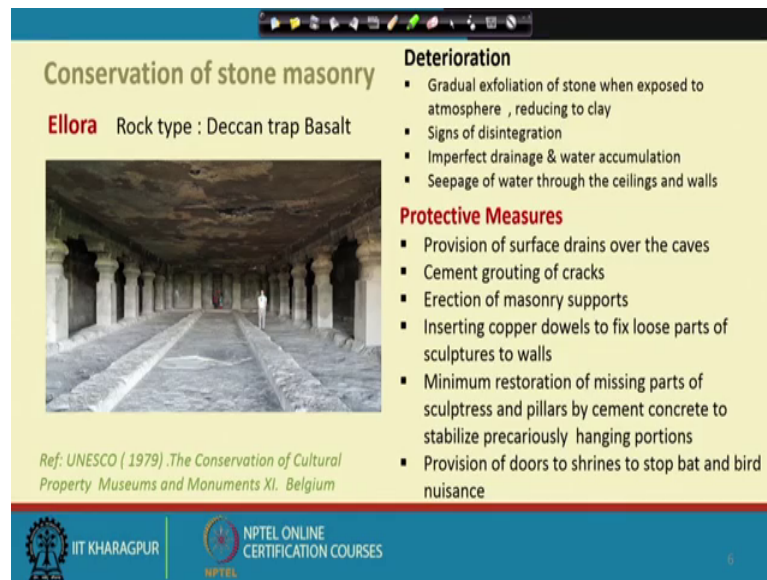
and the moss and fungus lichen which is happening on the roof. And in this case there are also problems of some of the columns which is supporting the structure were missing, it is a rock cut structure, and that required a lot of other measures, very drastic measure which has to be taken.

Now, let us see water in general the protective measures which were taken that time. The removal of all the earth vegetation and disintegrated rock from top of the cave, because that is where the water is coming, and it was very much required to stop that, and cement grouting under pressure from the top and back side of the caves. So, there is no water seepage through the caves. So, the grouting was done and repeated application of paper pulp in this case also you see to reduce the salt concentration, and deteriorated columns replaced by plain Ashlar masonry to hold the roof.

Many of these columns have been rebuilt to or constructed to hold the roof, and how they were done and other, there is some controversy, but let us see that in this case plain Ashlar masonry were there, and they loose or cracked parts of the sculpture internally secured with non rusting metal dowels. Some of the sculptures or structures and they are actually part of the missing. There is no attempt to rebuild that, but whatever is there to hold them in place was very important. So, non-rusting metal dowels doubles were required and they were secured with that, and cracks filled up with suitably coloured mortar.


So, these are in general the protective measures which are done for the elephant caves and the sculptures, and probably now you, and it is continuous method process which is going on there is a lot of tourist's pressure. The other types of problems which are happening; I think it is a continuous process which happen and happening and ASI is taking care of that.

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Conservation of stone masonry

Ellora Rock type : Deccan trap Basalt



Ref: UNESCO (1979) .The Conservation of Cultural Property Museums and Monuments XI. Belgium

Deterioration

- Gradual exfoliation of stone when exposed to atmosphere , reducing to clay
- Signs of disintegration
- Imperfect drainage & water accumulation
- Seepage of water through the ceilings and walls

Protective Measures

- Provision of surface drains over the caves
- Cement grouting of cracks
- Erection of masonry supports
- Inserting copper dowels to fix loose parts of sculptures to walls
- Minimum restoration of missing parts of sculptress and pillars by cement concrete to stabilize precariously hanging portions
- Provision of doors to shrines to stop bat and bird nuisance

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As you know that it is a world heritage site, a very important part. Let us talk about a Ellora; Ajanta Ellora are again the rock cut structure, and they have their almost a similar problem, but somewhere it is also very different you can see that that. So, let us see what is the rock type.

The rock type is a Deccan trap basalt, it is a different type of rock and it is the type of deterioration which happen is a gradual exfoliation of stone when exposed to the atmosphere, which is very different the one we have seen in the Elephanta Caves and reducing to the clay, and it is one of the major problem there were signs of disintegration, you can clearly look at the roof air and you can see that some sort of a problem is there, and imperfect drainage and water accumulation.

I always mentioned that water, sometimes is water itself is not a problem, the accumulation and the stagnant water is a problem. So, the proper drainage and stopping the seepage that is a very important measure so, here you can see the seepage of water through the ceiling and walls was again another problem. So, let us see what are the protective measures which happened here; the provision of surfaced drains.

So, the drainage of the water around the caves is very important, cement grouting of the cracks, erection of the masonry supports and inserting copper dowels to fix loose parts of the sculptures to the wall, almost similar to what we have seen in the Elephanta Caves,

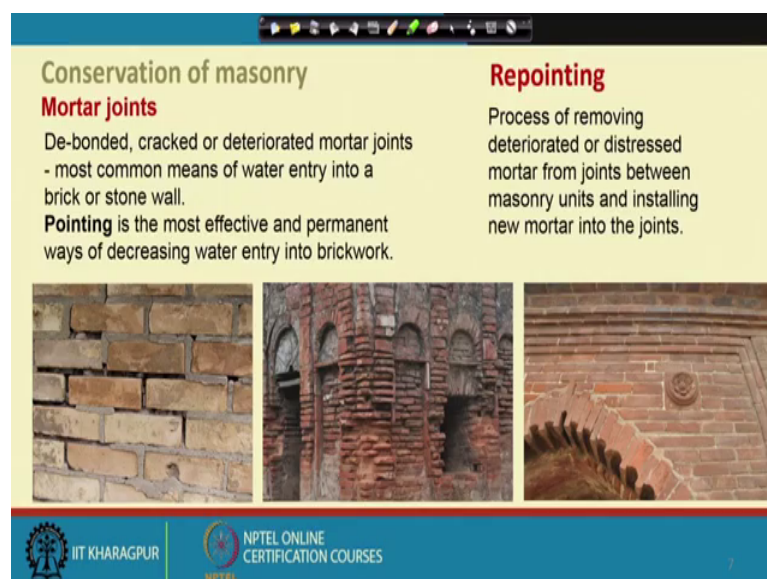
and the minimum restoration of missing parts of the sculptures and pillars by cement concrete to stabilize precariously, hanging portion. These are the.

Again you see that the principle of the minimum intervention was followed here, whatever was required it was done. Another problem in this case with Ajanta and Ellora is there. There is a large number of visitors who visit that and there is a free schools, so there sometimes coaches are there.

So, different types of in a very closed environment due to the humidity and other it creates a problem. So, now, there is a visitor management which is in place um, and also the problem of vandalism is also there. And another thing which has been done is that, if you remember that we have talked about the bats. So, provision of doors to the shrines to stop bat and the bird nuisance.

Now, this is some of the protective measures which will happen there and I am sure lot more is happening. There is a sort of a restriction on the number of visitor, there is restriction of the taking photograph, and using the flashlight other. So, some sort of a precautionary measure, management measure which is there, and recently the Japanese government has also put a lot of forestation a forestation around escapes to control the temperature or the environmental control, temperature humidity another in a large scale which has been done. So, these are some of the protective measures which has been happening in the Ellora.

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Conservation of masonry

Mortar joints
De-bonded, cracked or deteriorated mortar joints
- most common means of water entry into a brick or stone wall.
Pointing is the most effective and permanent ways of decreasing water entry into brickwork.

Repointing
Process of removing deteriorated or distressed mortar from joints between masonry units and installing new mortar into the joints.

The slide includes three photographs: a close-up of a brick wall with deteriorated mortar joints, a view of a brick wall with arched openings, and a close-up of a brick wall with a circular opening.

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Though also while discussing some of the major requirement and methods, if all these well known structures in India. Let us talk about the mortar joints which is again a very important part of the maintenance and the repair method. Now, mortar joints is a, when de bonded cracked or deteriorated, because they hold the Ashlar the stone or big in place. So, de bonded cracked or deteriorated mortar joints is the most common means of water entry into a brick or stone wall, and over the years it is sort of a deteriorates and that time what has to be done, how to do it, what is the technique ,which material has to be used, very important to understand.

Like in here you can see that it is a big structure and how the biggest whether, the mortar joints have sort of deteriorated and this will cause on further deterioration of the structure, ultimately to it will collapse if not much precaution or maintenance methods are not taken care of, but sometimes even something has been done, it can also be very injuries.

Like in this particular case of the brick wall what you can see is that that the cement pointing has been done there, the mortar joint, and that is something again more dangerous, because the weight is done and the material has reduced, because it is a much more stronger material which has been used for the pointing. And then what happens is that the water cannot come out of that. First of all the weight has been done is not proper, the debris has not been clean and so, and it is a stronger material.

So, what happened with the temperature fluctuation another, this is strong. One has not sort of a belief that if you give a stronger material for the joining; that is better, it is absolutely wrong, that because the joining should be should not be. It should hold the thing together, but it should not be stronger, because in that case what happens, the original material itself in that case the break that becomes deteriorated faster.

The joins is a stronger material and they do not behave in unison with the temperature fluctuation another thing and it cannot brick the water which goes inside that cannot come out through the pores, then it will try to come out through the bricks itself or the material itself and that cause more problem and the damage.

So, these are two cases that where something has been done which is injurious and causing further problem and where in this case; the something has nothing has been done so, in such cases pointing needs to be done. The pointing is the most effective and

permanent ways of decreasing water entry into brickwork and the stone wall also. Here this is a Vishnupur, you can see that pointing has been done with the lime water and in this case some of the new bricks also have been added, you can make out that and some cases the it has been, pointing has been done with the new lime water.

So, what is repointing, as I say this is the most important part of the maintenance and repair, how it is done, what type of mortar has to be used for repointing. So, it is a process of removing the deteriorated or distressed mortar. So, first it has to be taken out, there are techniques of doing that, the cleaning and other things, then only the repointing has to be done from the. So, it is a deteriorated or distressed mortar which has to be removed from the joints between the masonry units and installing new mortar into the joints, the different techniques for that the skill is required.

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Materials for building conservation

Pointing

Binding materials and mortar

- Lime – quick lime is used to prepare lime putty
- Sand – coarse and fine sand from local resources
- Brick dust (surkhi)
- Methe (Fenugreek)
- Jute in plaster
- Jaggery
- Brick
- Mud mortar for masonry repair work
- Ground water / potable water

Original materials should be tested in lab for mortar composition and specifications

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And now let us see, again we continue with the more pointing, with the pointing is not only the skill here, you can see the stone wall it is an it is a the Himachal Pradesh, Kangra Fort which has been, it is a photograph from there, the pointing has been done, it is a e tape protected side. So, pointing is actually the binding materials and the mortar and what material, how it will be done, again I am repeating that it is a very important thing.

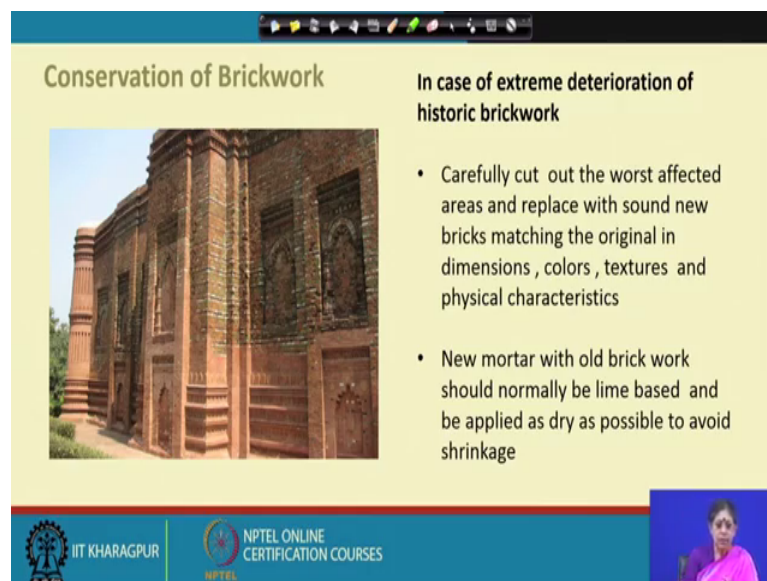
So, here you can see the composition is a very important, here some of the indicators, some of the common material which is lime, quick lime is used to prepare the lime putty,

it is again it is a process which is a very traditional system, sand, coarse and fine sand for the local resources, brick dust what we call locally as surkhi, the methe the fenugreek, it has also property it has been traditionally used, the jute in plaster it has the it sort of acts as a binding material, the jaggery which also as an adhesive of the brick, mud mortar for masonry repair work and groundwater a potable water, the quality of water also has to be need.

This is a general sort of a prescription, but place to place structure to structure the, depending on which period it was built this composition may vary, and we must sort of try to see that what was the original nature, and there are it has to be tested in the lab for proper composition, proper specification and then only one can go and see that what type of material has to be used for pointing.

And as I say the material is important, adhesive definitely can be mixed, but one has to be very cautious what is the adhesive in what proportion, what is his impact on the major masonry work, and the skill that how it has to be done, and the cleaning, the processing there is a step by step procedure, which has to be taken properly care of. Does a see pointing in the old masonry structure is a very important part in terms of skill and the material

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Conservation of Brickwork

In case of extreme deterioration of historic brickwork

- Carefully cut out the worst affected areas and replace with sound new bricks matching the original in dimensions, colors, textures and physical characteristics
- New mortar with old brick work should normally be lime based and be applied as dry as possible to avoid shrinkage

The slide features a photograph of a historic brick building with arched windows and a staircase. At the bottom, there are logos for IIT Kharagpur and NPTEL Online Certification Courses, along with a small video inset of a woman speaking.

Now, when we talk about the brickwork; you see this is from north Bengal Malda and good there are a lot of historical structures there, and there were old ceramic tiles. They

were a colour which were there and if, as you can see that some of the portion of the bricks are original and some of the bricks have been replaced and when the bricks have been replaced and some have been cleaned and the. So, when had been replaced, when do we replace that. So, this is in case the extreme deterioration of the historic brick work.

It can be replaced and so the part is that the carefully cut out the worst affected areas, it does not mean you take out the whole wall, only the part which is very badly affected, you take out that part, carefully cut out and replace that with sound new bricks matching with the original in dimension, in colour, in texture and physical characteristics.

So, this is a very good example where ASI has been doing over the years, carrying out restoration work, maintenance work and they have been kept there, as you can see that some part is old, there are the marks of original colour or the ceramic tiles, and they have been kept in place only the place which has been badly deteriorated the bricks have been replaced.

And new mortar with old brickwork should normally be lying this and this is again and again, which is very important the line where it was used, it was a slow setting, it has in own property, it is much more comfortable the material wise, the use of cement is not at all desirable, some admixture can be given that again I am saying after tasting and depending on what is the behaviour. So, as I say in the new mortar with old brick is required sometimes should normally be lime based and be applied as try as possible to avoid the shrinkage.

So, these are some of the major maintenance and repair methods which are talked about, and as you can see that this is needs a high skill, a lot of knowledge for each and every specific structure. It needs a multidisciplinary the structural engineers, the materials specialists, the laboratory experiment, the skill and training of the crossman or the labourers, mason, and the botanist who can talked about what is the thing, the chemist. ASI in archaeological survey of India they have a very multidisciplinary team work with continuously working on this, and these are some of the maintenance and repair method we have talked in a very briefly in these two lectures.

So, with this we are coming to this sort of we discussed so far about the historical monuments, and they repair, the decay, documentation process. What we will talk about in the next module, is that we will talk a little poor macro scale, that means which is not

only the individual structure, it is also what is important is that the areas, this historic area districts where there are some more structure new structure, how they happen. So, the our next focus in the next two modules, we will be talking about the historic district areas, the adaptive reuse are the new structures, and later on we will go again we will come back to that some of the disaster mitigation methods, which we will talk about at the end.

So, this is we are completing one phase of the discussion of the various aspect of the conservation of the historic structures.

Thank you.