Architectural Conservation and Historic Preservation
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Lecture - 28
Investigation and Conservation of Historic Structures Case Study 2 (Part a)

In the last lecture, we talked about leaning tower of Pisa and we have seen that how years of leaningness of that was ultimately diagnosed and the solution was not so difficult, but the diagnosis and a proper investigation and a multidisciplinary team contributed and avoided a great disaster that could have happened. Today, we will take out another interesting case study where we will see that how the investigation research and years of understanding about group of work can save a very important structure. So, and continue with the investigation diagnosis and conservation measures.

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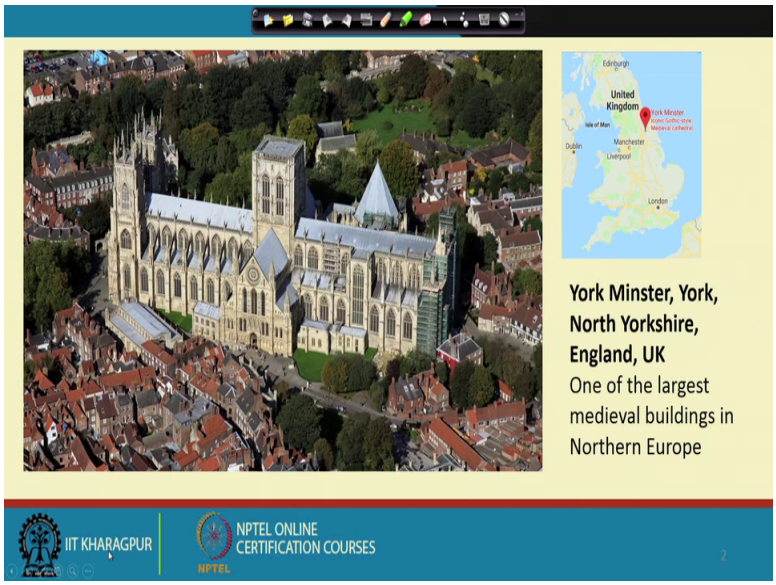

Today, we will talk about York Minster in York; in North Yorkshire in England, if you can see that this is the place, this is one of the largest medieval buildings in the North Northern Europe. So, beautiful cathedral still functioning, but it is very interesting story and lot of interesting stories. So, we will try to see that how and what is happening and what has happened.

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York Minster in peril; so that was the news on the front page of the Yorkshire evening press on Friday, April the 7th, 1967, what did this say that central tower could fall after 15 years and as you can see that the central tower is a very important is almost 60 meter of height and if this sort of collapses and it would be very difficult, it is a disaster because in the field of religion also and of England, it is very important and its beautiful structure.

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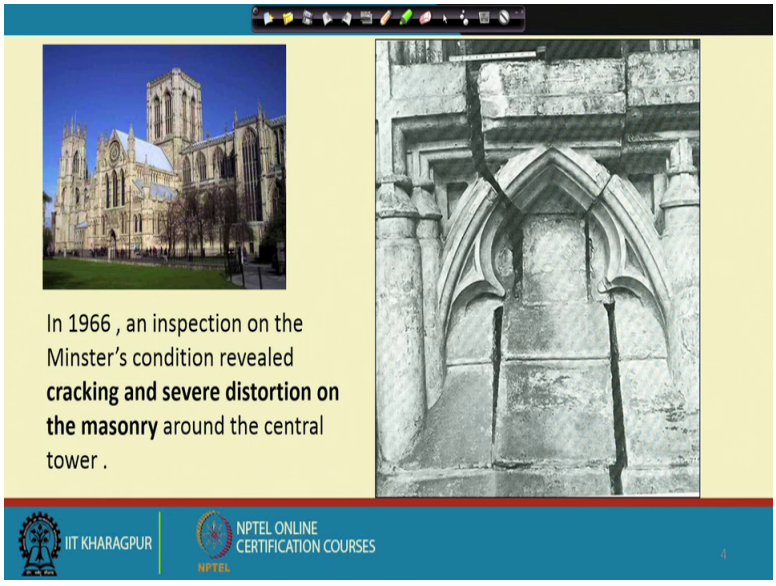

So, this was the situation, it can see the cracks which happen and there were cracks all over, but suddenly, it found that the cracks probably, it was widening and I mention that when there are cracks, one has to understand whether these are life crack or a dead crack. So, in 1966, when there was a learning science and inspection team on the minster condition revealed cracking and severe distortion on the masonry around the central tower, it looked like the cracks were still continuing and there is danger.

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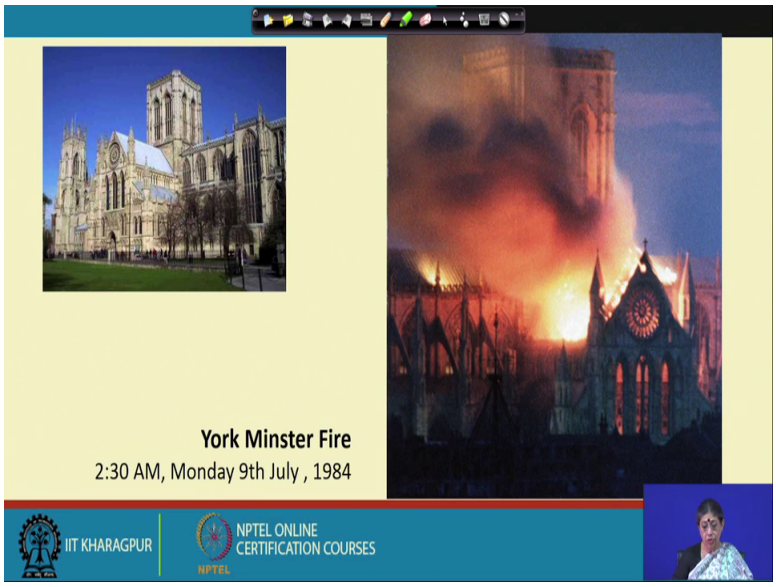

This another event which was happened, we will talk about the crack later on because we will take 2-3 instances, what happened in York Minster a great fire also happened in the very recent history of York Minster that York Minster fire which happen in 1984 on 2:30 AM in the night, Monday, 9 July in 1984, it totally destroyed the South Transept of York Minster. So, these are the two events or disasters which struck York Minster will talk about that one by one and we will see that what has been done, how it has been diagnosed and what are the conservation measures have been taken to bring it back to its former glory.

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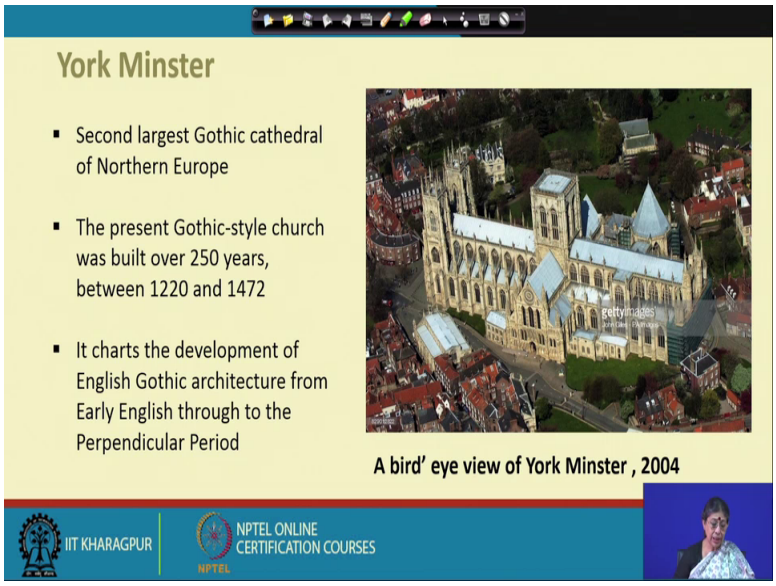

So, before that; let us talk about or see that what is York Minster and what is its historical background and what are the historical timeline, what it happen, what is its importance. So, this is bird eye view of the York Minster in 2004, you can see it is so beautiful and it is a gothic cathedral, it is the second largest gothic cathedral of the northern Europe and the present gothic style church was built over 250 years between 1220 and 1472, but his history goes back much before that it charts and also it is important is that it charts the development of the gothic English; gothic style of architecture from early English through the perpendicular period. So, it has recorded say it is a very important architecturally also rather than being a very important religious structure.

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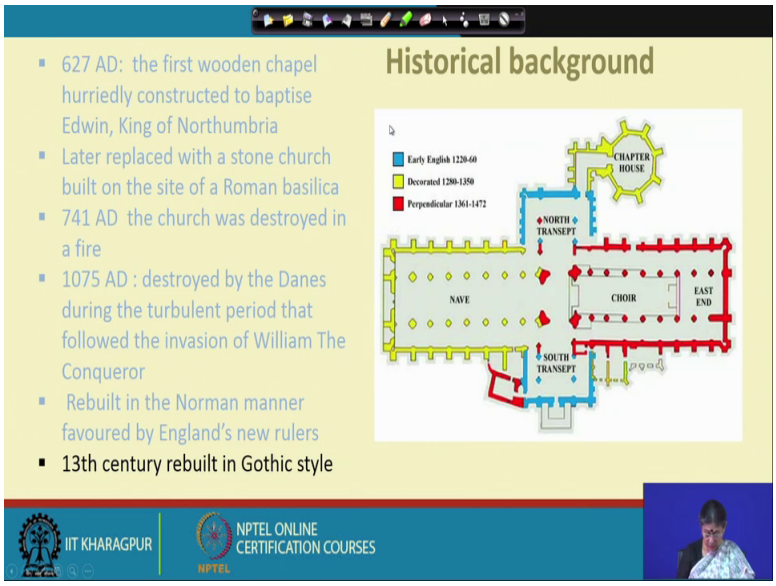

So, let us see the historical background that what happened to the site and how did this beautiful cathedral gothic style cathedral came about the history goes back of that is site goes back to 627 AD when there was a first wooden chapel which was hurriedly constructed to Baptise Edwin the king of Northumbria. So, that was the first recorded history of this place later, it was replaced by a stone church built on the site of a Roman Basilica we have mentioned discuss about Yorkshire that the Romans did come there and you may still find a lot of roman reigns of that time.

So, it is it is believed that it is replaced early stone church on a which is built on a Roman Basilica 741 AD, the church was completely destroyed in a fire and 1075 AD, it destroyed by the Danes during the turbulent period of William the conqueror, remember that the York your Big Viking museum and which we discussed and it actually that time dense came and they actually conquered and they cause a mass devastation and these actually that church that time was destroyed early stone church was destroyed by the Danes.

But again it was rebuilt in the Norman manner favoured by English new rulers. So, as the rulers will changing, the architecture style was changing and accordingly, the church also underwent the various reconstruction restoration and repair and rebuilt stitch 13th century, it was rebuilt in the gothic style which was very favoured that time and as you

can see in this map or the plan of the Yorkshire that you can see that clearly there was an early English period.

So, this is the part which is an early English period and then you can see that this is another period which is from two thousand eighteen to thirteen hundred and fifty and the perpendicular style which we are talking about is this part which is shown in the red colour what is to be is very important for this first example what we talked about of first case or instance which we will talk about is this portion the where the great tower of the square tower is happening.

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This is what it is today beautiful interior the grand scale stainless windows all over the world cross walls decoration beautiful place, it is and still being actively used for religious purpose as well as the tourist and visitors come there.

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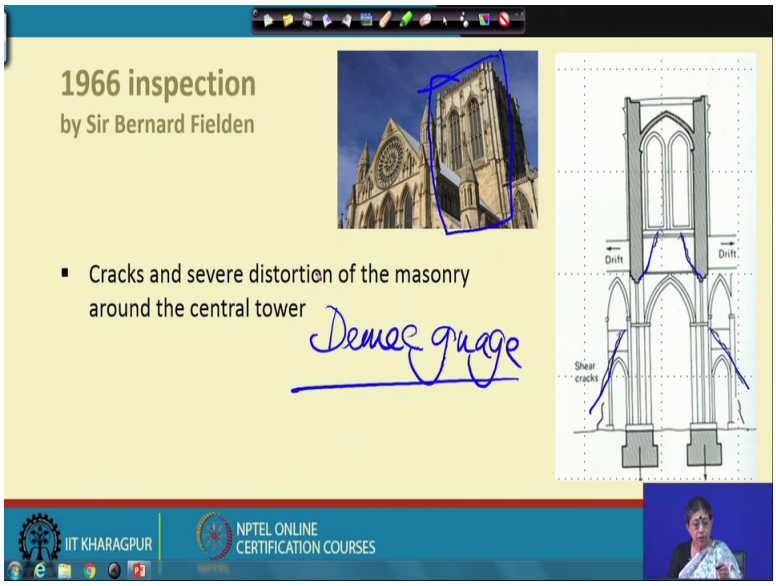

So, let us talk about the that go back to that crack which was very alarming and they said that it will it has a life only for fifteen years. So, 1966, that Sir Bernard Fielden with this team inspected that there was a various type of investigation which happened. So, it was found that the cracks and there was severe distortion of the masonry around the central tower.

So, this is the central tower what we talked about that this is the central tower and this is we see it in a section and there were huge cracks which were evident that time there is one sort of a instrument which is called Demec Guage which actually is able to measure the or not only whether the cracks are live crack or death crack they also if measure the which direction the cracks are widening and other and whether the cracks a live crack or death cracks; that means, whether the crackers still continuing or not. So, this was recorded with instrument the various cracks were recorded during that time.

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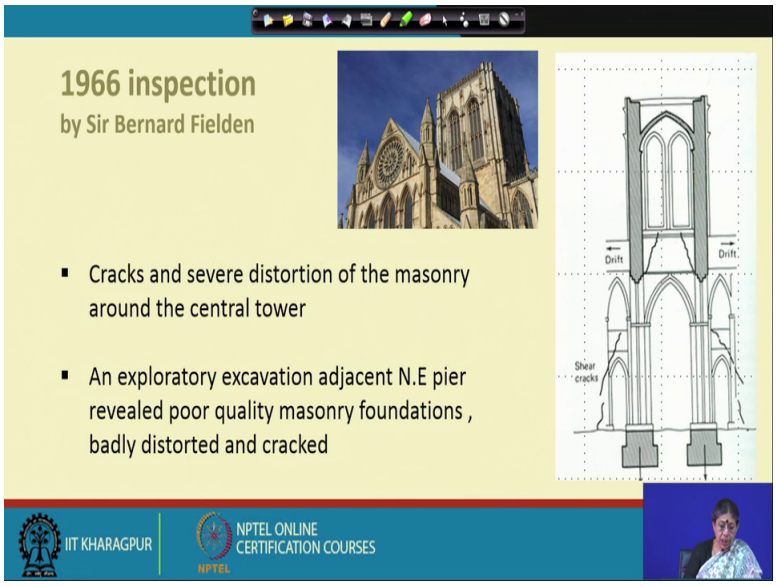

And in addition also it was necessary to do an exploratory excavation adjacent to north east pier which revealed poor quality masonry foundation badly distorted and cracked because it was all happening the they were science of cracks in the various parts specially around the central tower , but also a while this excavation was happening to explore that to see the condition the it was found that the situation was very severe there were large caping holes within the foundation and it was almost surprising that how this huge load was being still taken care of.

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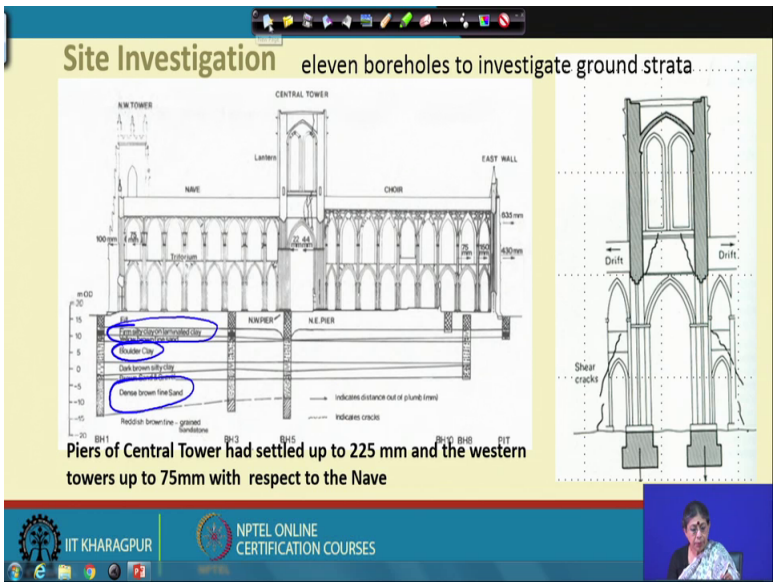

Now, what was done is that 11 bore holes were put drilled through the soil to investigate the ground strata and you can see that this is the start did the various types of ground strata, it is found that the ground condition when this boreholes were dug and it is found drilled through that that it was not a similar condition, it was a very composite and a variable type of soils are there and it was also found that the taking the plumb line the settlement was not equal.

It was found the piers of the central tower has settled up to 225 million millimetre and western towers up to 75 millimetre with respect to the name. So, what is found out that the settlement which was happening is not equal, it was different in different parts of the huge structure and if you see the different types of clay, we can clearly see that there are bolded clay there are the different types of sand were found which are there and there are silt also which are there different types of clay which are there. So, it was every composite type of soil which happened.

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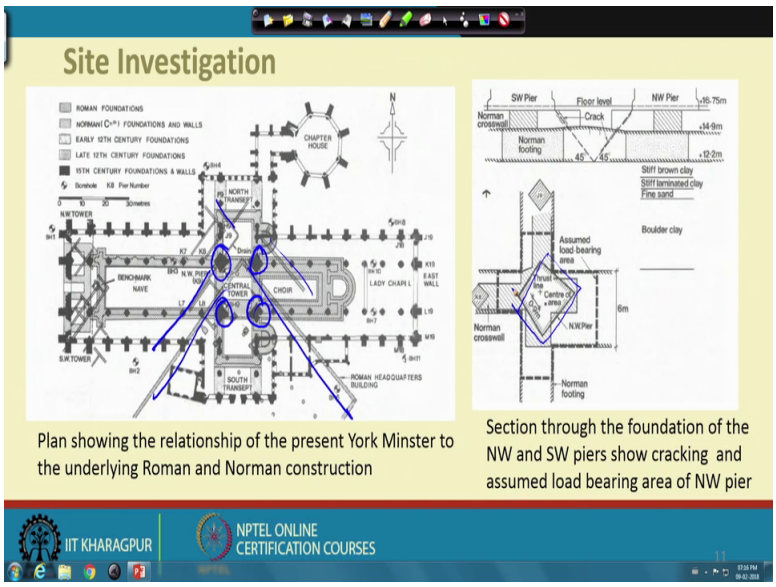

Now, let us look at the plan of the here you have seen earlier. So, it was found that there is a plan which showing the relationship of the present York Minster to the underlying Roman and Norman construction as we saw the history historical record that there were various types of structures which are there they were not so big, small, wooden and stone and they were rebuilt and there were distort and they had their own foundation and one part of that these huge structure came up and also in stages.

So, here you can see that it showed the how the present that four a the central tower which is there, how it is the supreme post on the Norman foundation and it is not actually matching. So, part of the two of the towers are on the Norman foundation and the other towers were outside the Norman foundation and also this Norman foundation the weight was built it is very different there were used to have wooden piles and this wooden pile also changes there condition because of the groundwater level.

So, there was also a change in the groundwater level of these city because of the organisation and other factors now you can see another section here which shows the northwest pier which is there the foundation of that and how they are in an oblique manner it is position on the Norman tower. So, it is partly on that. So, of this central tower of the 4 pier two are on the foundation of the Norman pier and the two are outside the foundation of the Norman pier and these it was a lot of structure calculation study analysis was done along with the investigation plan line the depth the settlement.

It was found that this there was definitely an unequal settlement because of this ground strata and the different types of foundation and different types of buildings which were there because it was inhabited right from the beginning. So, different types of constructions were happening on the same site now what was done is that to diagnosis what was the cost it was understood that it was a due to a different settlement.

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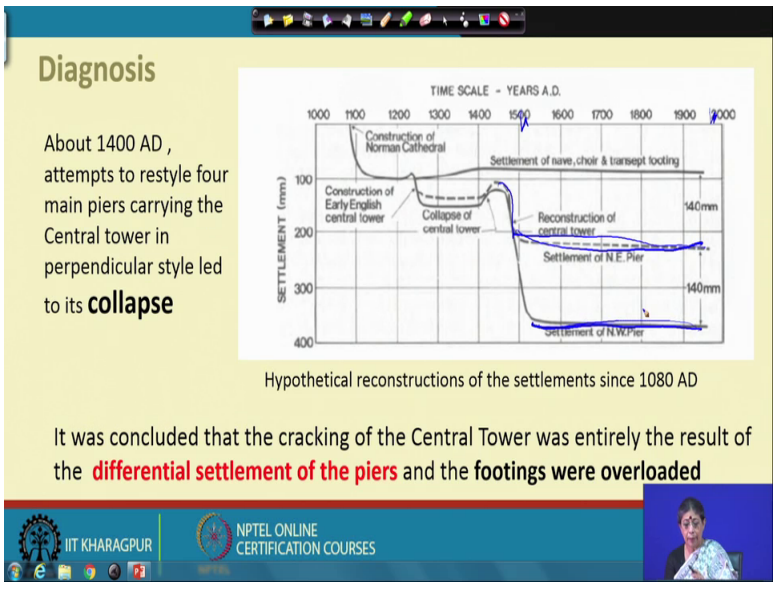

What is done here that is an hypothetical reconstruction of the settlement since 1080. So, this was done according your timeline and that what was the settlement the churches are very good in keeping the records. So, they had their record and if you see that the in initially this sort of a settlement was there during the construction of the normal cathedral and then there was a time when it was a sort of almost it changes it becomes slower ah, but again in this time there was also collapse when the of the because about 1400 AD, there was a style, the main power and there was a central towers collapse. So, that is the history which you found there.

But also then after that that certain settlement happen, but again as we can see here that at this point that there was a differential settlement of the north east and the northwest piers. So, I mean, but that also stabilize over this period of 1502, almost middle of a 1900, it almost settled, but around that time in 1960, suddenly it was found that the settlement was certainly sharply happening. So, this was became us, but it was from all these reconstruction and diagnosis and various types of investigation excavation which happened it was found that it was I mean decided or they came to the conclusion that the cracking of the central tower was entirely the result of a differential settlement of the piers and the footings were over loaded.

So, this was the diagnosis after a sort of a multidisciplinary team working for a long time and different types of investigations which happen now the question comes of the diagnosis investigation was there then the diagnosis was done now the question come what can be done what are the remedial measure because otherwise this type of crack happen, it is definitely bound to collapse.

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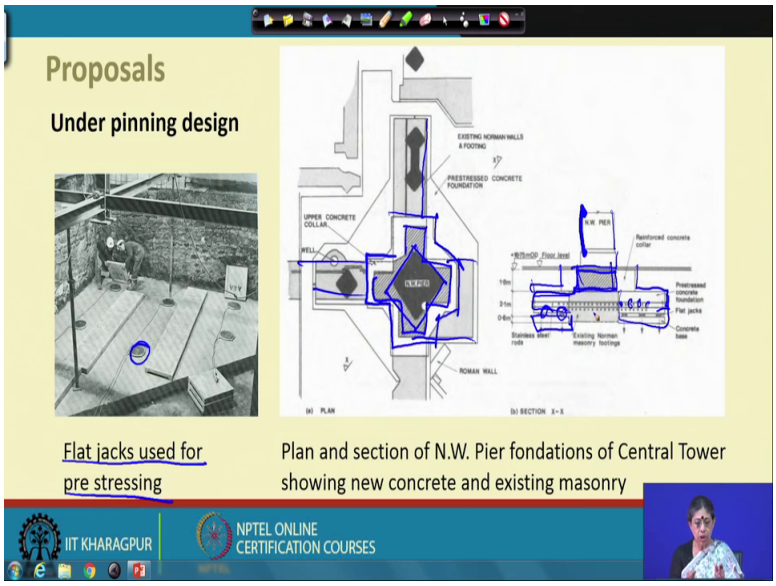

So, most of the thing in the available solution in such cases is underpinning underpinning is that you sort of strengthen the foundation construct foundation from beneath and make it stronger because it is not able to take the load any further and for the underpinning also there is a different alternative scenarios are there they were discussed the various options were tried I mean discussed about that and then ultimately a particular solution was decided and in this case, it was realised that because this type of composites, all in a huge structure is there the moment the underpinning will be done.

There this will also create a further stress on the surrounding condition of the adjacent structures of the parts of there and that you can create a further problem. So, the thing is that even if I strengthen the foundation from beneath the underpinning that will create a stress on the soil, but how to sort of reduce that impact became a challenging situation and for that it was decided that there will be pre stress what actually done if you can see here that this is the northern pier which was existing this is the Norman foundation.

So, what was decided that to put or put it in a sort of a concrete collar and widen the foundation from beneath and from the site and then so that these new portion and the old portion can work in unition and whenever it will like to press the soil and there will be a settlement the moment there is a settlement happening there will be a sort of an adjustment. So, that the differential settlement is not much it will sort of adjustment will

be there and that adjustment we done by the flat jacks which were inserted and that flat jacks will again try to counter balance the settlement which will happen.

So, if you see this section here. So, this is the northern pier and this is the Norman church Norman, this is the old sort of a foundation which was there. So, now, what is being done is that this extra sort of a part which was constructed and these extra part which was constructed at two parts one is this part and another is a lower part of platform in between this flat jacks which were inserted and they had a sort of lubricant.

So, the moment is trying to sort of settle down and put a pressure on the sort this flat jacks with sort of give a pressure. So, that the differential settlement is not happening and also there were sort of a bar pre stress bar which should be horizontal bars which will be put through the old foundation and the new foundation. So, that as a whole they work unition.

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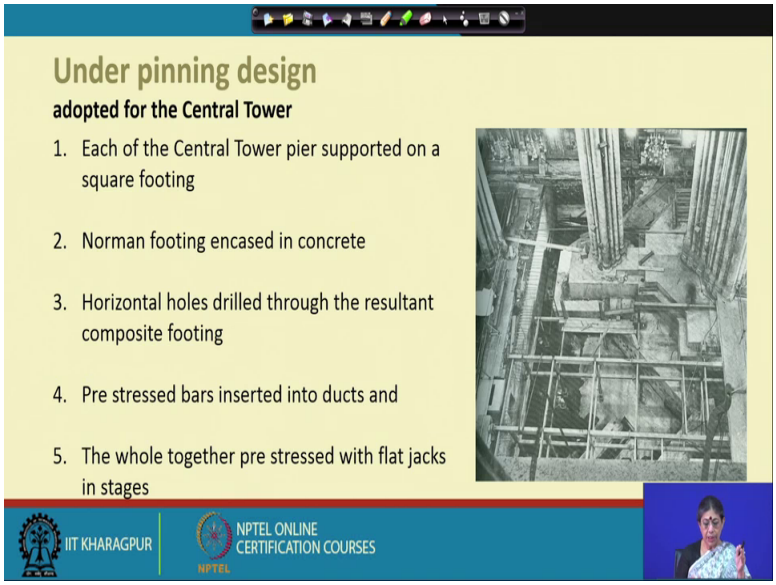

So, this is a clear picture of the clearer picture that what is happening to the old foundation and the new foundation the underpinning the pre stress what has happened and you can see that this is the old section and then the new section has is coming up there and there were these horizontal time members or the things which was going through that and in this new section also there are two parts in between there are flat jacks which were again try to because whenever there is a pressure on the soil, it there will be some adjustment happen there will be settlement when the question here is to

how to reduce the impact of the differential settlement and that actually was sort of a tried in this restoration of the York Minsters underpinning.

So, now what is the process each of the central tower pier was supported on a square fitting footing and the Norman footing was encased in the concrete as I showed in the section and the horizontal holes drilled through the resultant composite footing. So, that they work in unition and the pre stress bar were inserted into the ducts and the whole together pre stressed with the flat jacks in stages and this was happening in stages not at one go.

So, that it takes time, but it will try to settle and the practice and happened further and there is no further differential settlement it was marvellous bit of structure genius it was done with all of associate and filled it as a teamwork and this was really appreciated all over and it became an exemplary work of foundation strengthening and saving York Minster from collapsing.

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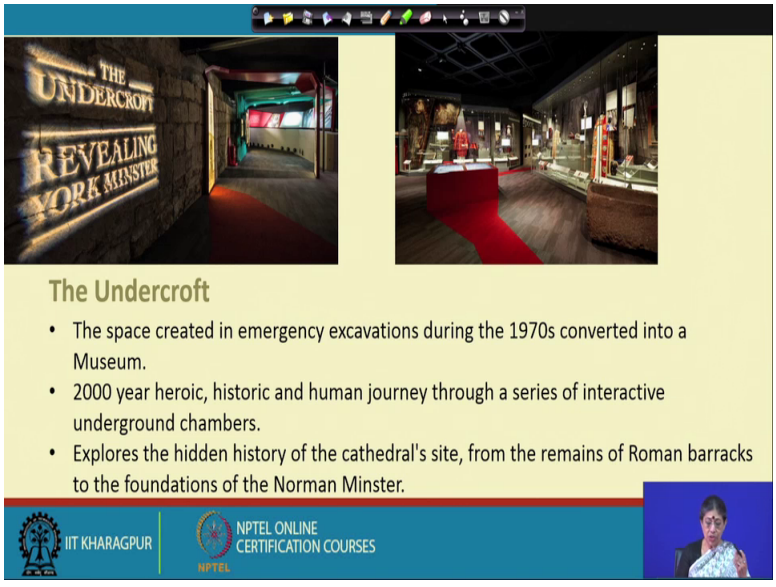

But another way wonderful thing happen when this excavation was doing for the investigation and other and the foundation in the basement was created it could have been filled up this is a marvellous a sort of innovative idea that this Undercraft which has been created because of the excavation it was converted into a museum museum to show the it was done for the emergency excavation, but it was to show the two thousand years

of heroic historic and human journey through series of interactive underground chambers.

It is very interactive you can also see the old Norman foundation the Norman foundation the restoration which has happen is clearly visible and one can move through that Undercraft and see what has happened and this explores the hidden history of the cathedral site from the remains of a roman barracks to the foundation of the Norman minster and thousands of visitors come visit the Undercraft there of York Minster, there is a society it raises funds at the same time it works as a religious place the choir and the sacred practices all happened.

So, this wonderful example that such is huge impact which was going to happen it is going to collapse and how through a proper investigation a diagnosis and understanding the research of the historical records which are found the understanding of that what is happening and trying to find out that what can be the solution it was no normal fit, it was a fantastic a structural thing, but what also is very important to see that not only it stop there, it try to take this opportunity and excavation which was created to convert into something or interpretation bringing it to the public notice and create a beautiful journey through history and that is one of the restoration measure which happen in York Minster, we also mention about the fire, we will talk about that in our next lecture.