Earth Sciences for Civil Engineering Part-2
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Active faults and its related hazard in India (Part-5)
Module 2
Lecture No 8

Welcome back in the last lecture we talked about the active faults and we stopped at while discussing the 1995 Kobe earthquake.

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Now let us move ahead and I will start with this slide where we were talking about that how the surface manifestation look like ok.

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And then previous slide if you look at we talked about that how if there is an sub surface displacement how this there is a manifestation on the surface so we, we talked about the fault scarp which you can see here and then this is the displacement here, so net displacement can be taken up between this two units ok.

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So let us move ahead so this was the one of the devastating earthquake in Japan in 1995 and the picture which you are looking at here is the surface rupture of 1995 Kobe earthquake, we will go into the details of this.

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Now as I told during that in the previous lecture also that Japanese government what they did, they they preserved this surface structure and they they made the bill the museum on this fault to create an awareness ok, so this is extremely important because for the society because this is whatever the whenever there is a big earthquake there is a lot of damage and a lot of people are at risk because of the this sudden catastrophic events ok.

So people should understand like what exactly happens during the earthquake and how there is a surface manifestation and how geologists look at it. So like as I was taking about that if you put any structure on on on the active fault without having understanding that what sort of movement it will be and first of all we should avoid putting structures on on the active faults.

But even though there is no other alternative if we have to cross the structure and we have to put the structure on that, so we need to understand that what will be the movement and what type of displacement it will result in when there is an earthquake. So this is an example which shows that there if if you look at this wall here, this wall got displaced at the time of the earthquake in 1995 Kobe.

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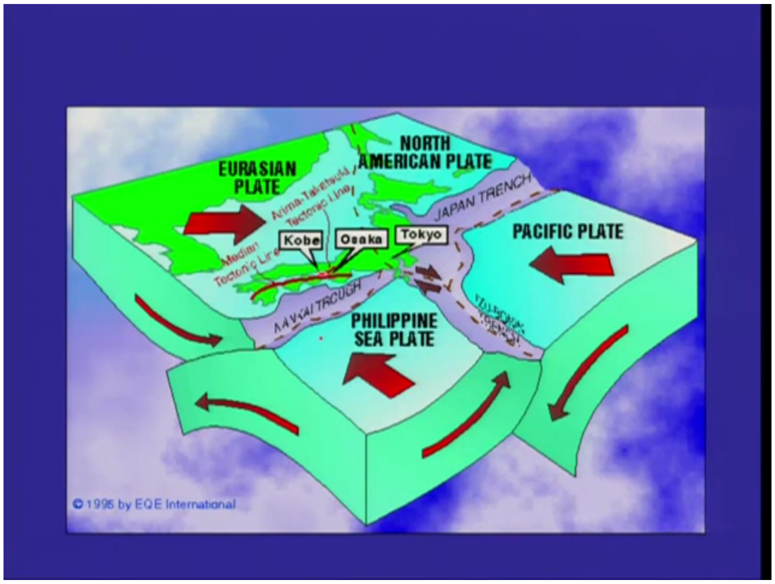

Now if we in a broader sense if we look at Japan the Japanese our ends ok, they are the result of the ongoing subduction between the Eurasian plate, Philippine plate and Pacific plate and Philippine plate and the American plate and Eurasian plate ok. So this was what is the broader configuration of the tectonic sitting of Japan.

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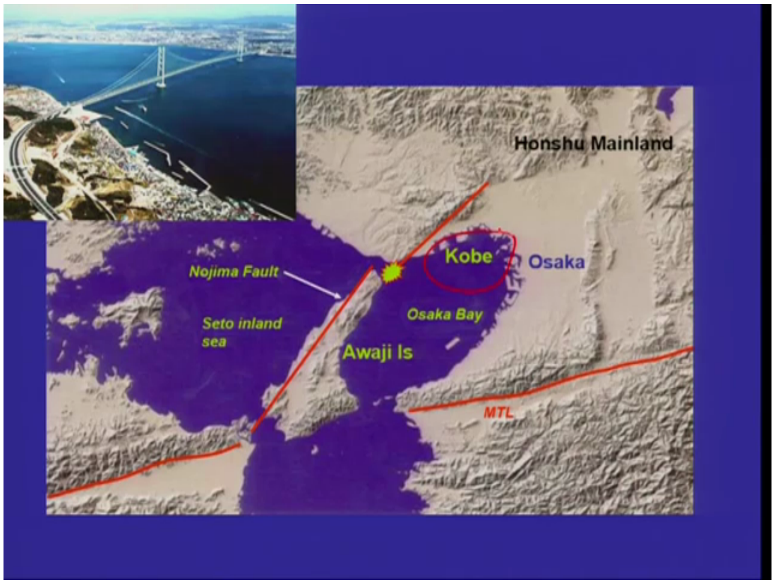

Now if we move ahead what happened in 2000 1995, that the rupture started and the main earthquake was along the the MTL Median Tectonic Line, this is very similar to San Andreas fault system with right lateral strikes with motion and the earthquake was triggered somewhere here and the rupture propagated on either side and the extensive damage which was been observed was at Kobe because of the soil conditions and all that.

So this fault they named as Nojima fault, we will see some surface manifestation of this earthquake which Japanese people measured after the event, so this passed through, so if you look at this point exactly, this is what the two islands are been connected through this project, so this bridge also the peers of this two bridges ok, this this this side and this side the fault passes in middle and they were also been displaced little bit ok.

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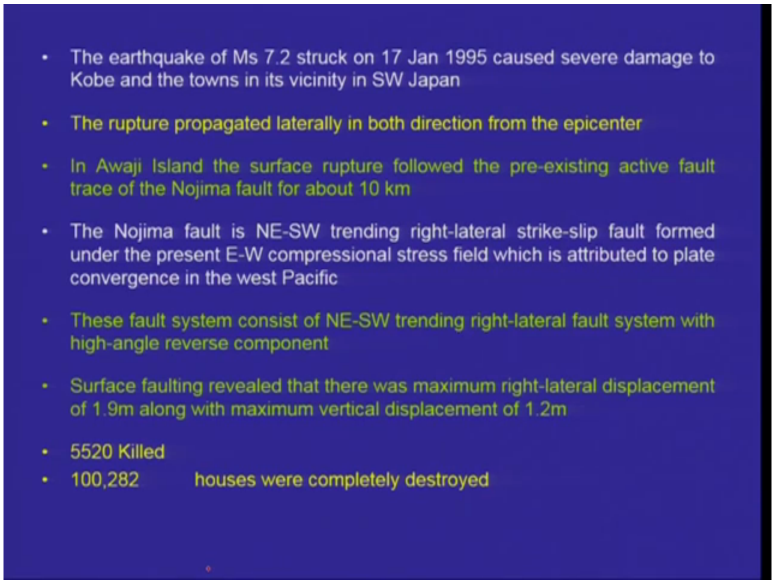

So the earthquake was of magnitude 7.2, it occurred on 17th Jan 1995 caused severe damage to Kobe and the towns in the vicinity of South of Japan. The rupture propagated laterally in both directions of the epicentre as we have seen in the previous slide ok. The Awaji Island, the rupture was seen in the Awji Island ok, it was more prominent and that was along the Nojima fault and it was been traced for almost 10 kilometres.

The Nojima fault is North East South West striking right slip fault, right side, right lateral slip fall and this is found due to the east west compression stresses ok, stress feel which is attributed to the plate conversions with the specific plate. So I will just briefly talk about this, now what was most important if we in terms of what we should look at is the surface fault if you look at here ok, surface fault will reveal that there was a maximum right lateral displacement of 1.5 metres along with maximum vertical displacement of 1.2 meters, so the fault moved laterally as well as it resulted into the vertical displacement also, so the land was been moved laterally along the strike by 1.9 meter and around 1.2 meter it had an vertical displacement.

So this is very much important to understand when an earthquake occurs and we need to know that what type of fault it will be and what type of displacement we will experience ok. Around 5000 people have been killed and then how around 1 lakh houses has been destroyed, so this was the alarm to Japanese government that they need to take up this type of studies in more seriously and that what they did actually, so after 1995 maximum studies were been carried out in terms of identifying the Palue earthquakes and in understanding how individual fault is behaving and what will be the expected recurrence interval in future along those particular faults.

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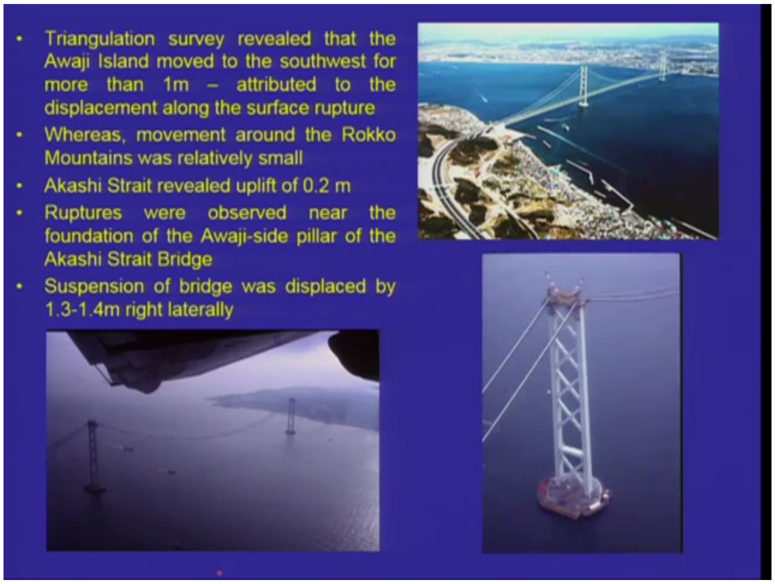

So this is what they they identified that there was slight shift between the two peers of of the of the bridge almost like and there was an uplift also of point almost 20 centimetre or so ok. And since suspense and bridge was been displaced by almost 1.3 to 1.4 meter right laterally, so this is the important part which I have been talking about that, we need to know that where exactly the fault passes, nothing happened to the bridge and but there was an severe damage in that area.

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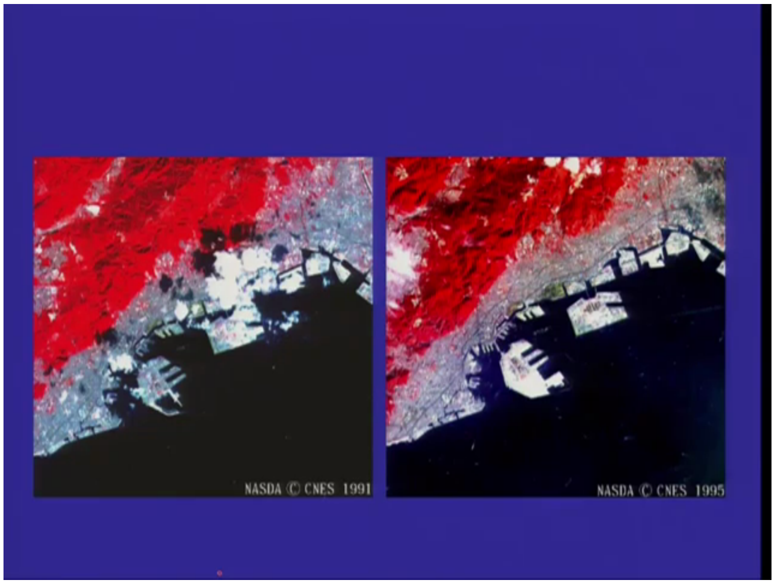

So this is the the the satellite picture which shows the pattern of damage after and before, what happen if you see here, this was the damage area which was been covered.

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This is Kobe area and sever damage this you might have seen in many books, this photograph the bridge was been extensively damaged, main bridge and this are the photographs of that.

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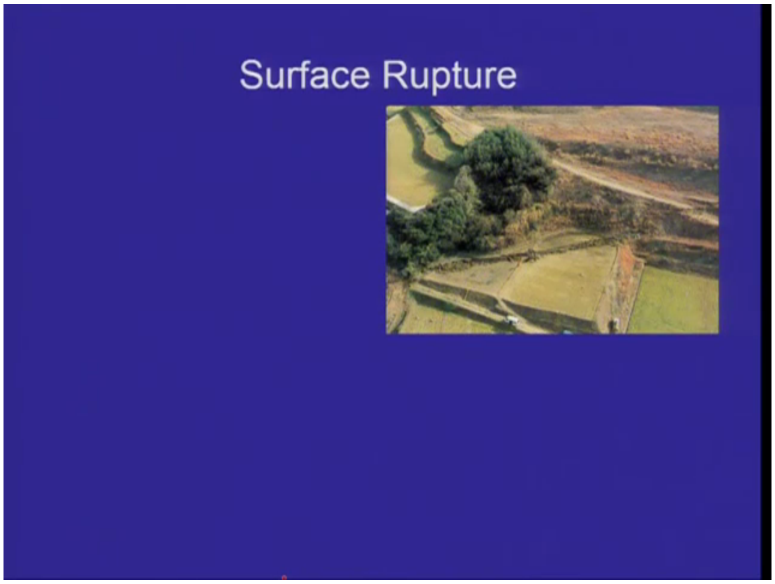

Surface rupture, coming to the surface rupture this was the trace which was been identified and we will see a close up of this how it looks like ok this is something like that ok, so you have an vertical motion here and one close up of this one.

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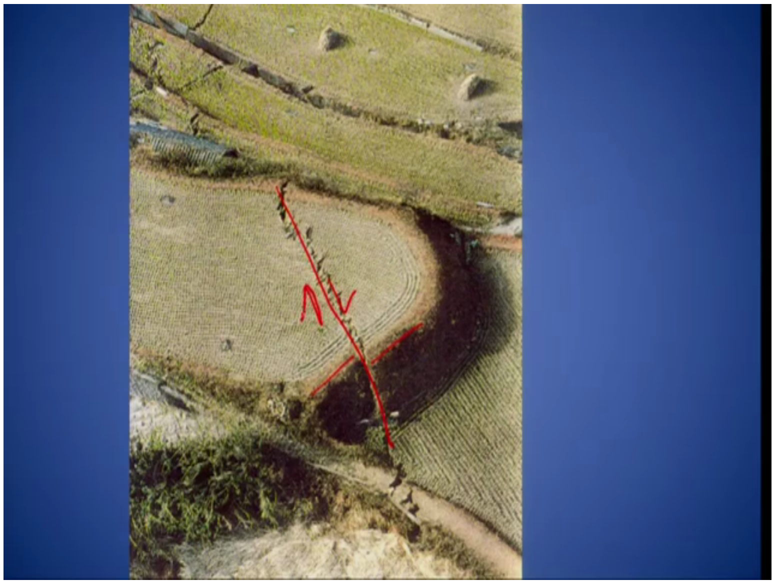

I hope we have ok and if you look at this part, this is an agricultural field or the agricultural boundary which was been displaced, this is the boundary coming here and this is for here ok, so this is the rupture here, this one, so the fault moved like this.

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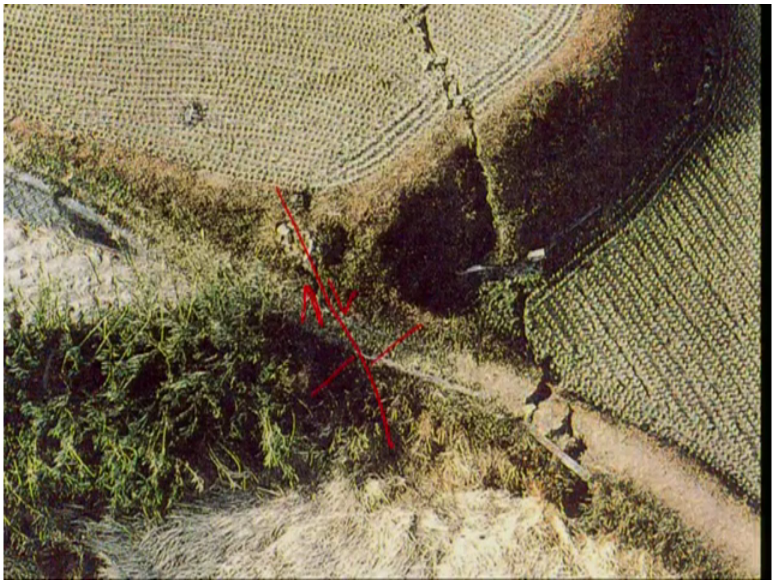

Close up of that and see the rupture on the top of the surface.

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And what we we found was the striations ok and this photograph is from the edge of this one.

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This photograph has been taken from here viewing like this ok.

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So this what it shows is the striations, this indicates again that in the direction the fault moved, so if you see clearly here there are very fine striations or the polish surface which was resulted because of the the movement and the wall moved like this ok, so direction of the movement is like this.

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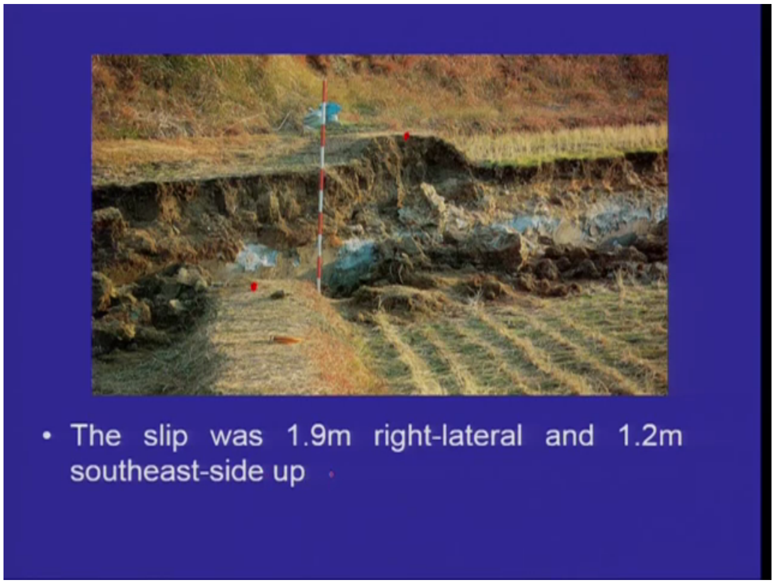

Now if you compare the the the piercing point like this is the agricultural boundary here we are having over here now ok, so this point and this point ok, so you have an vertical displacement also and you have lateral displacement, so the slip, right lateral slip was around 1.9 meter and then vertical slip was almost like 1.2 meter, so it moved right laterally and it moved vertically also ok.

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There is another view of that surface structure which you can see here, close up of that one.

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So several small scale fishers were also developed along with that and most common phenomena which is what we call as a secondary phenomenon mostly seen in or observed during an earthquake is liquefaction and lateral slip, so lateral spirit or lateral slip of the land is also another commonly seen affect and those are secondary effect ok, so other than the faulting which is resulted on the surface or the the fault scarps which are seen on the surface.

Because of strong ground shaking you will be able to observe or experience the land slip which is if you are having a very low angle slope than also you can have that and then the liquefaction ok. So this is an example which you see here is of lateral spirit, in a proper sense we can say is a is a land slide ok and then we have liquefaction occurring.

So along the fishers we will have the liquefied material which is coming right up to the surface and this is extremely dangerous because if you are having a structure sitting on such soils (()) (12:03) than the that structure will collapse because the soil will lose the shear strength, so in Indian in particularly if you are having a big earthquake or large magnitude earthquake in Himalaya, lot of problems will be faced in terms of liquefaction in the Indo Gagentic plane because we are sitting on a loose soil, we have the very and and the water table is also very low ok. So we we will have liquefaction problems in the Indi can city plane.

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So the they preserved this old rupture in in a form of a museum.

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And they also took up, took this house which is now a part of the museum and you can see this, the rupture is going over here like this and then there is a displacement which can be seen over here ok, so this this boundary wall got displaced right laterally, so if you can put here like this than it goes like that ok. So fault runs here, so you are having the movement like this here, so this is important like we we need to know where exactly the fault goes, so we should avoid putting structures on such fault lines.

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There is a close up of that, another close up of this one, you can see the offset of the the boundary wall.

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What they did was they they created, see this is the museum which they have created after this ok.

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So this part goes into the museum, so they excavate it trench which shows the section view, sectional view of the fault and to show the people ok, so they have like they have the this is the rupture coming up and this is the sectional view and then this is the horizontal view of that ok, so they dug this and they have preserved so they put the glass on this one, so the people can walk down and move on the on the on the fault itself and try to understand what exactly happen ok.

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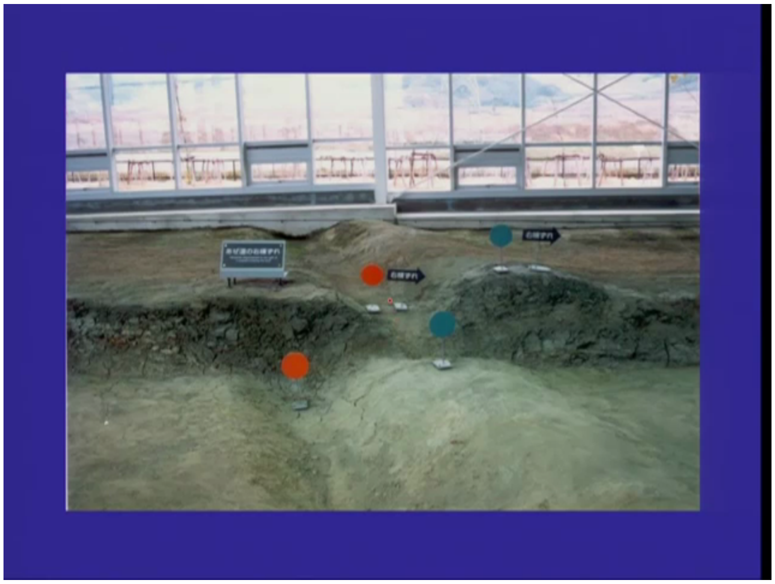

There is another very good example which is been preserved again in the museum which shows the the small plain ok in the, in the forming land which got shifted, so these are the piercing point two pink and blue which shows the the points which were in the surface which were together before the event.

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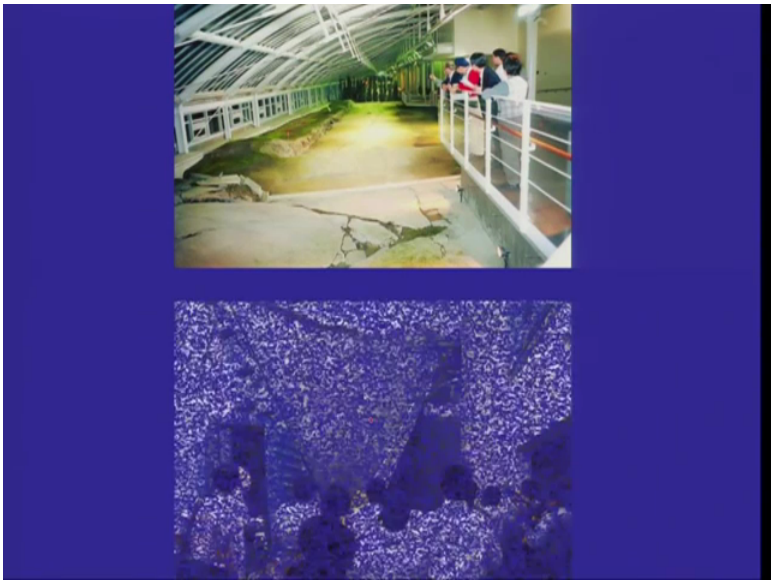

So this is what people do ok and try to look at what happened in 1995 Kobe earthquake.

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So there is a very small movie which I hope it will play. So this is a small video which I took when I visited this place where you can see the whole rupture how it is been preserved ok. So this is this is extremely important for all of us to understand that how rupture looks like and what happens during an earthquake ok.

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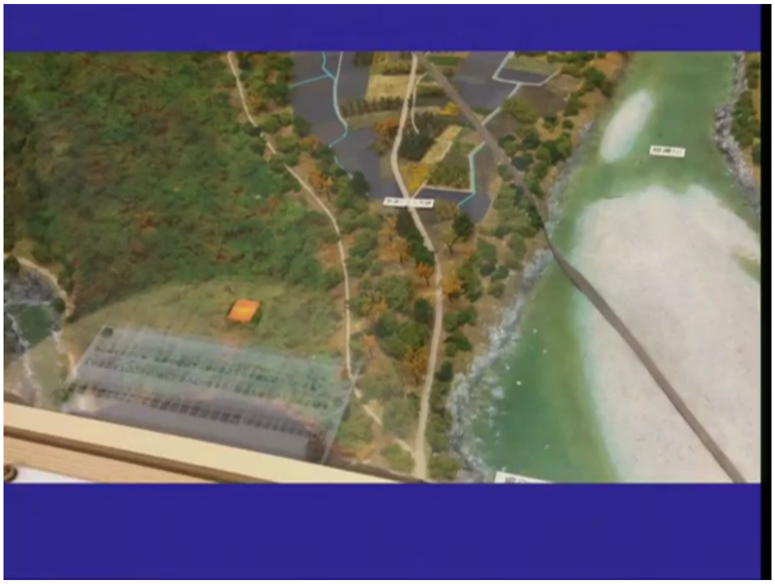

So moving ahead this is another which they have created which again gives an very good idea about that what happens during an earthquake. So if you carefully see here somewhere you will be able to see that what happens during an earthquake the land is coming up and then there is a displacement on on the surface ok. So this is model which they have created and they have tried to make people understand, they can see the wall which has come up here now, so this is what happened during large magnitude earthquake in Japan.

So this is a part of their exercise which usually they they have done for some earthquakes, so this you can see now how how the displacement will occur ok, so this is multiple events ok not the single even it can be multiple event which will occur and this is a person who who was behind this actually Kakashi Nakata who who created all this idea and then he he approached the government to do that ok.

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So now there is another like this are the other four signatures of of the the earthquake which is again preserved and they have not disturbed at all ok.

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So this is recent photograph which was been taken where you can see the stairs have been displaced over here, so you can see the displacement over here, the stage boundary should have gone straight but it has displaced along this line. So these are some very important aspect which we should have in in most of the countries and many countries have followed this and tried to make create awareness amongst the amongst the people, this is extremely important, so there is a shift here and this is a close up of that one ok.

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Now liquefaction and lateral straight was very common in the areas and the costal zones where they reclaim the region ok, so this is the reclaimed areas where we can they had massive liquefaction, so all white spots which you see here are the liquefied sand which came up through the through the sand pores.

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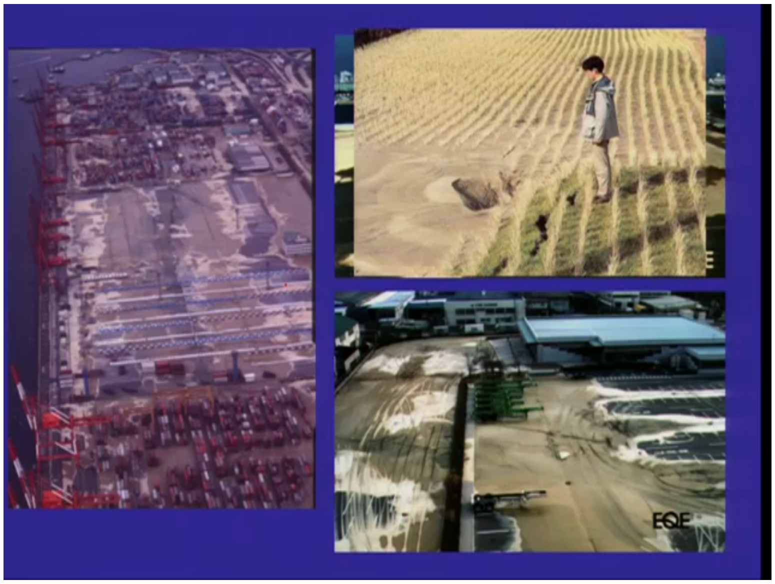

So in the harbour areas you can see the liquefaction problems which they faced and then a sort of an pot holes or we say the sand blows which were been created because of the liquefaction.

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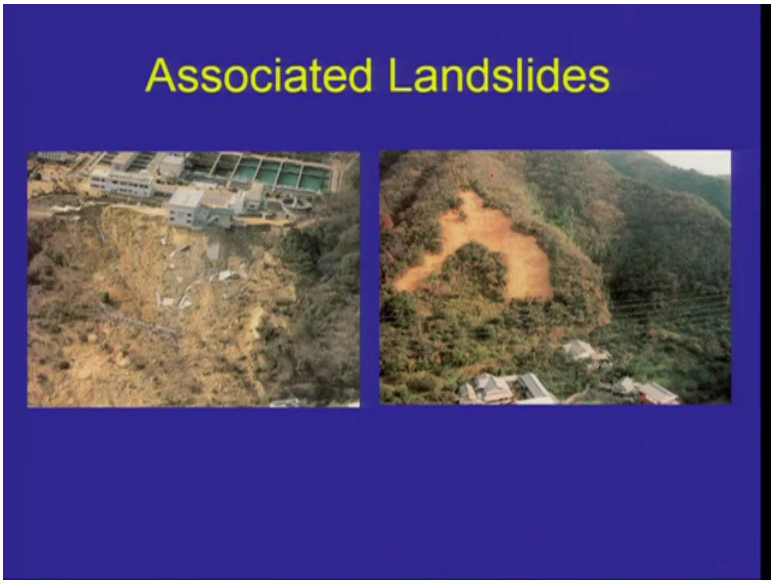

Now as you associated land slide ok, this is another problem which is commonly observed after each earthquake ok or during an earthquake we have these problems which we need to face ok in the hilly areas maybe.

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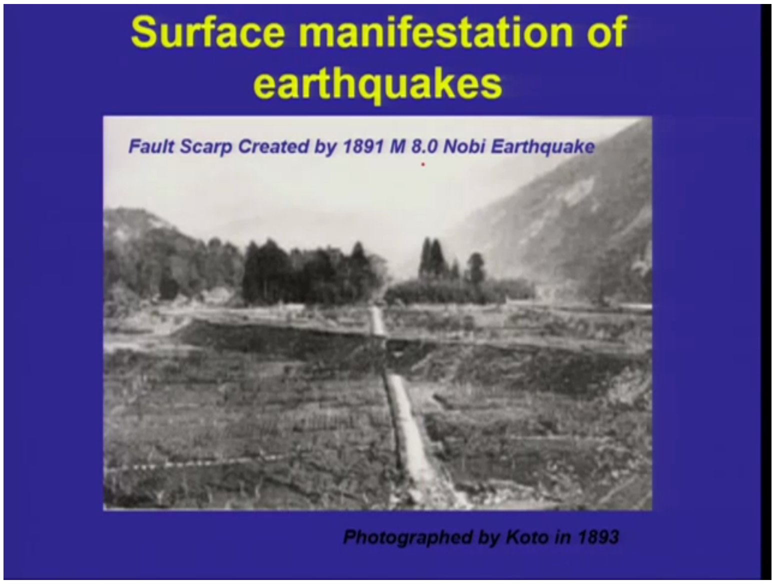

So this is another event which was magnitude 8, Nobi earthquake again in Japan which shows the faults scarp over here, the photograph is not so good but you can see at least the displaced area here, so it was in 1891.

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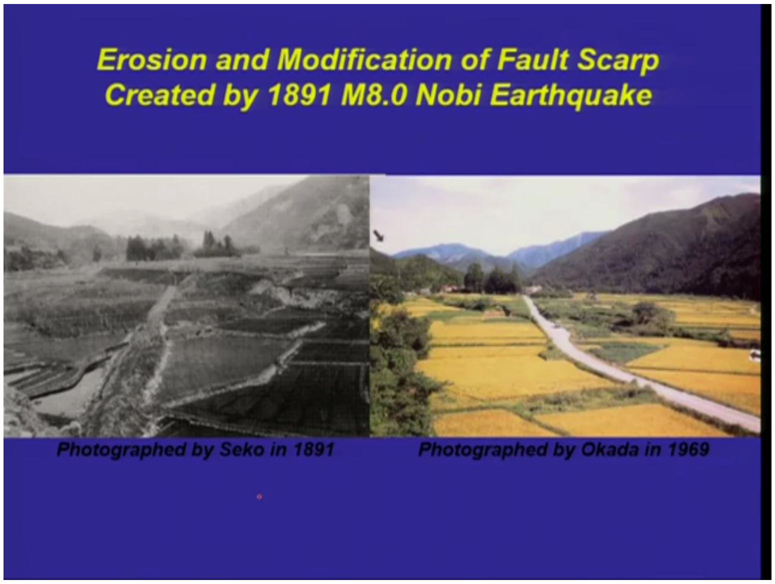

So this photograph was been taken in 1891 and then you can see the recent one ok but still that surface rupture is been preserved on surface, no doubt you can see the road which is going across it but the scarp is over here, this is the scarp which you see in this photograph here.

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But those those faults are well marked in Japan another photograph of which was been taken by professor Okada in 1974, previous one was in 1969 the same guy he is taken the photograph of this one ok, so how the the things have been modified and still it exists which is almost been modified now here ok, so fault runs here ok, so they still, still you can see the scarp here. So the question is that can you identify the fault, the act of fault in this, yes off course, if you understand that the land from displacement and the morphology of the fault then you can identify the act of fault and that's what we have been doing in India along Himalayas and in Kutch region.

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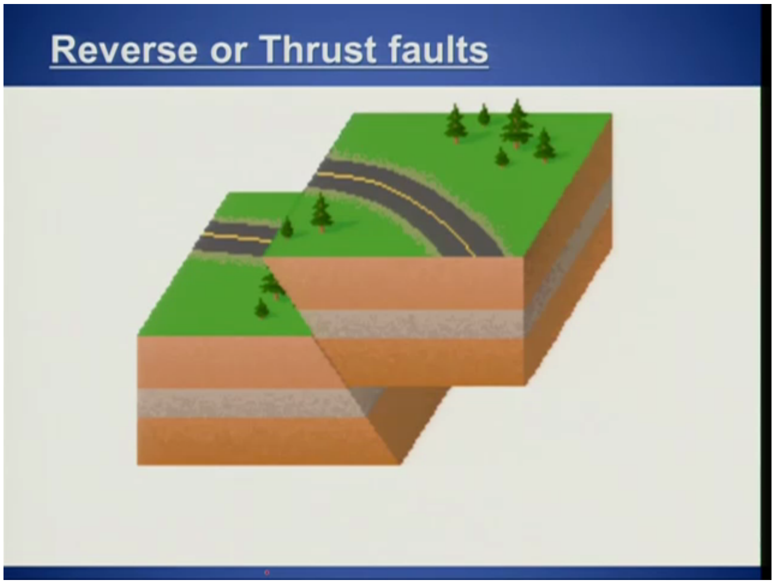

Now coming to the reverse and thrust falls here what we have learn in the previous course also and then during this like couple of lectures before that the hanging wall will move up with respect to the full wall and mostly this type of deformation is been seen in the accomplishment tectonic and the best example if you have to look at is along the Himalayan zone ok.

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This is another photograph of the active fault area photograph which is been taken, which shows the trace of the thrust fault or the reverse fault over here, which has displaced the young land form ok and that what would we do is, we try to look at that whether there an displacement of the young land forms or not and try to with an experience, we try to differentiate or (())(21:27) the fault scraps and because similar erosion, erosion features can also leave similar features on the surface ok. So that has to be neglected and then we can we can say that ok fine, this is an act of fault does not an act of fault scarp something like that ok, so we need to, we need to have the experience to identify such things ok.

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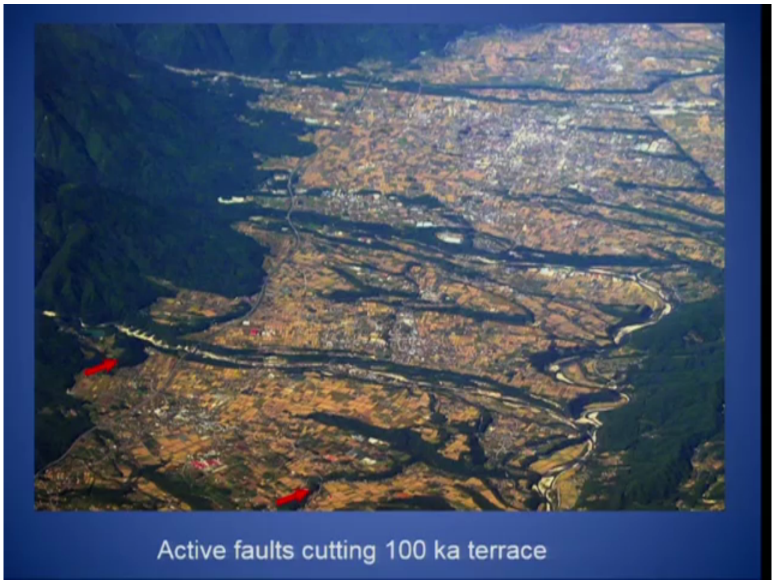

The fault traces has been strong here by the arrows where you can see this the star (())(21:59) portion is an a scarp and which has displaced the surface ok.

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There is another example of 1995 Chichi earthquake, we can see that the fault passed through the the playground and the the running track was been warped ok and this is a typical fault scarp which one can expect during the reverse fault or thrust fault earthquake.

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Another photographs of the same, you can see the warp here, so 1999 Chichi earthquake in Taiwan.

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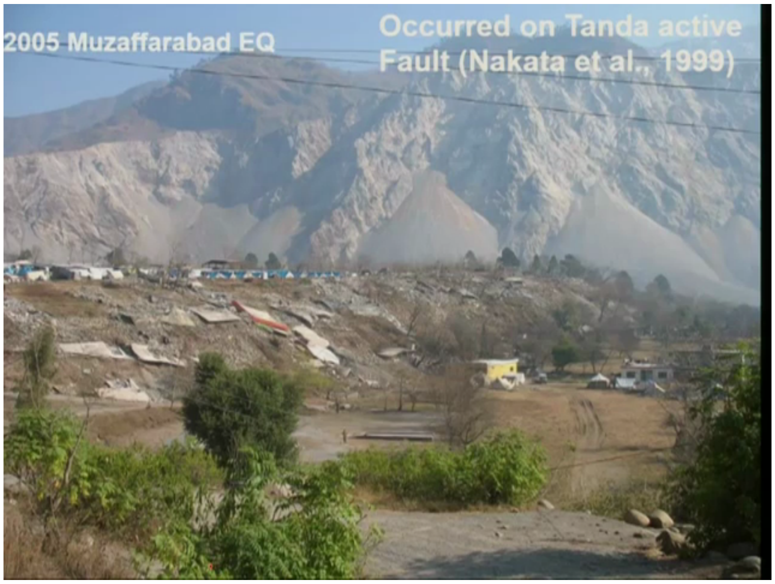

And coming to this ok, this is another one which occurred in 2005 ok. Now there is a small story behind it that this fault scarp which you see now here ok, was been identified by the by the professor which I was showing in the video Takashi Nakata, he identified in 1999 named that Thanda fault. Now this report was been submitted to the geological survey of Pakistan and he categorically mentioned that this fault may trigger a large magnitude earthquake in near future but they didn't believe him because they said oh fine, this is only 16 kilometre, 13 to 16 kilometre long fault how it can trigger a large magnitude earthquake.

But based on his experience and the work which he has been carrying out in Japan and India since last 30 to 40 years he mentioned that ok and and this what we experienced in 2005 was Muzaffarabad earthquake, the same fault ruptured and we had lot of life lost ok. So this is a fault scrap which can see and most of the this the flat line structures are are the the houses which were been raised to this ground during an earthquake, this so this is an hanging wall this is an foot wall here.

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Another example from India, at this what where we have been working as a part of the project sponsored by the ministry of earth science on active fault mapping in Himalaya, so this is another scarp similar to what we I was showing in Pakistan Thanda fault, this fault we have named as Hajipur fault and this is this exist on on the lift bank of the Vyas river. So you can see the uplifted part here, so there is a this if I just put a profile here, it will be something like this ok, so this is, there is a fault here which has moved like this ok. So this is an hanging wall and this one is the foot wall.

Now if you look at the question comes that why this guy has put the the house on top of this ok because he is not aware of the the active fault, he is not aware of he might not have experienced the earthquake, off course because the earthquakes recurrence may vary from 5000 years to 1000 years or large magnitude earthquake of magnitude 7.8 or around 8.

So the and the life span of the human is not so much, so people keep on forgetting ok, so during this decade or maybe in the past couple of decades we have not experienced an major earthquakes in Himalayas ok, our studies suggest that there was a major earthquake in 1500 AD ok, 1400 to 1500 AD it was somewhere around that, so we we have not experienced any earthquake after that in this region.

So probably because of the the less awareness people have built the houses here ok, so when we were doing our work in this area, people asked that there is no problem ok, only one house has been built on this but the point is that so more people will come around and have their houses here, so one guy came, another guy will come and they will have more houses on this but this but this should be stopped ok. So this is fault an scarp, Hajipur fault scarp and fault runs somewhere over here ok.

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So coming to the strikes slip, as we have been talking about the 1995 Kobe earthquake we will have the lateral movement and if we are having the oblique component clubbed with the the strike slip then we will see the vertical displacement also. So geomorphic markers associated with the the strikes fault, we will see very briefly what we should look at ok.

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Figure 4.1-4: Displacement of crops rows during the 1979 Imperial fault earthquake.

So there were been offset of land forms mainly what we see is the river or the (reteresses) river terraces or we can say the flat lines ok of the river and all that.

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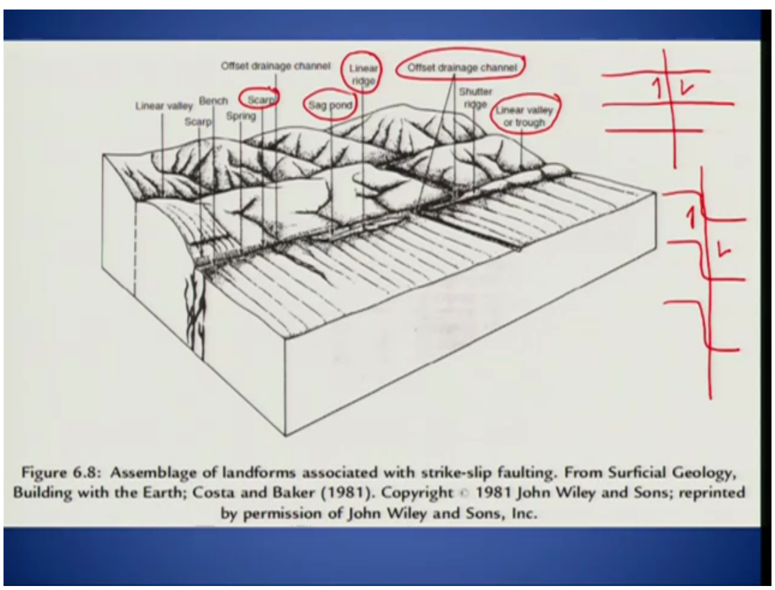

Figure 6.8: Assemblage of landforms associated with strike-slip faulting. From Surficial Geology, Building with the Earth; Costa and Baker (1981). Copyright © 1981 John Wiley and Sons; reprinted by permission of John Wiley and Sons, Inc.

So in in geological terms we have classified that what all different land forms we will see we will not go into that much detail but few of them ok, like for example what we will have we will see in terms of if there is an strike slip fall, we will see a linear valley formation, of the linear valleys along the fault then we will have offset of streams ok, so suppose the stream is flowing like this ok and then the fault is crossing here and then suppose there an right lateral displacement of the fault ok then what will happen, we will see the streams are coming like this ok, if you remember I have talked this when I was showing this slide on on the San Andreas fault ok, so this is what will happen.

And along with this the land forms will also get displaced ok which will result in formation of the sack ponds, result in formation of the linear edges, so these are the and of course we will have the scarps also ok. So this is what the most important features we will be able to see along the strike slip. We will continue in the next lecture, thank you so much.