Natural Hazards
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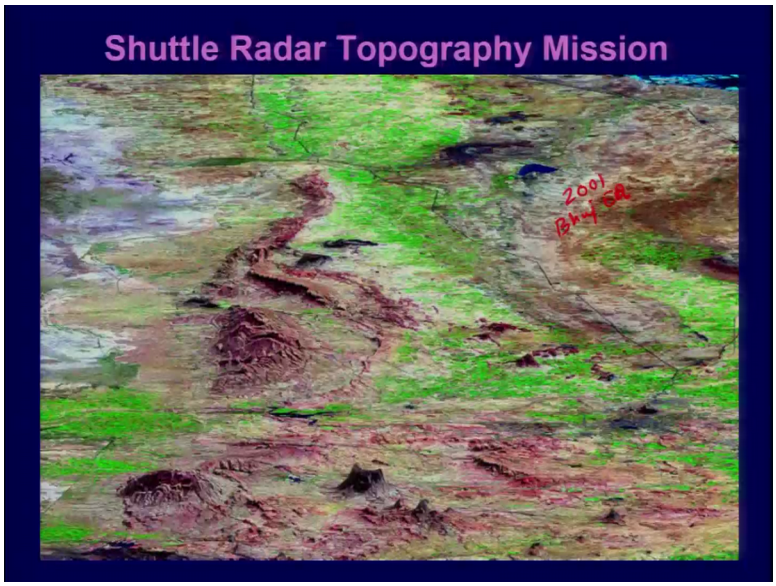
Lecture - 21
Ground Effects and Evaluation of Earthquakes Hazards Part III

Welcome back.



So, this was the last slide where we were talking about the phenomena of liquefaction which was observed in 2001 Bhuj earthquake. And, as I told that in most of the region which was we can say the low lying regions with near surface saturated soil liquefied during 2001 Bhuj earthquake ground shaking this ground shaking was quite intense.

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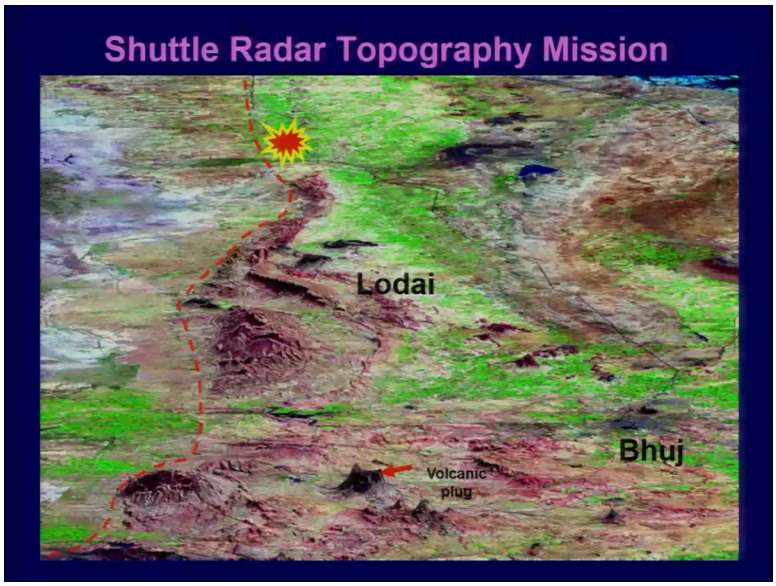

And as I told that the people local people they believed that this is the time when there is an revival of rejuvenation of the ancient river which used to the bulge in this region underneath the Saraswathi. So, this was the epicentral area and I will show couple of slides what we recorded after the earthquake the ground deformation in this region.

And also in this lecture I will show the liquefaction features which we observed and noticed from the great Rann of Kutch. So, mostly the hard rock area of course, also experienced severe shaking because the epicentral was not. So, far from this region and this whole area most of the cities and the towns were devastated.

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So, this was the data which was been captured after 2001 Bhuj earthquake, this shows in particular a region south of the main rocky land that is the main land Kutch and this region is your Banni plains which shows the liquefaction in Rann and Banni plains.

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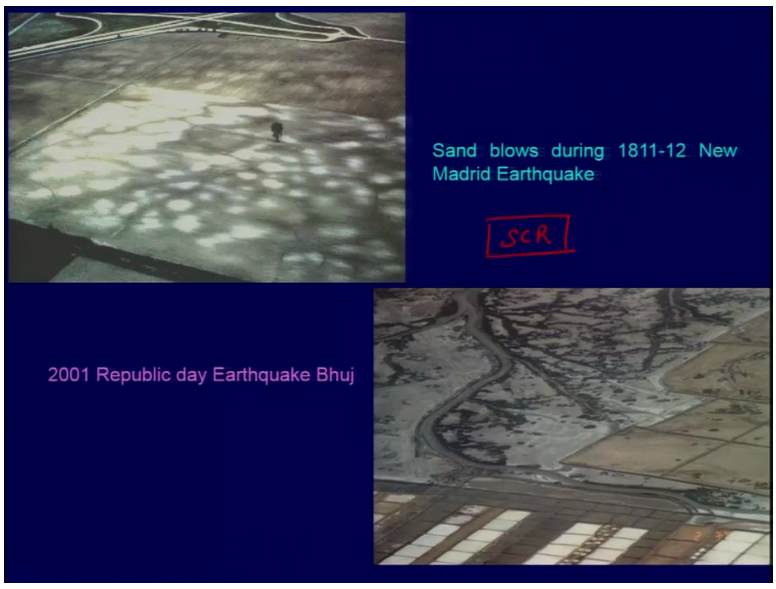

These are the pictures from new Madrid for the earthquakes which were been triggered in 1811 and 1812 in US and this was this is the picture aerial photograph which we took after the 2001 Bhuj earthquake in Gandhidham area.

So, this is the coastal region and most of the areas and this what you see is all of the tidal channels and the square white squares which you see is the salt agricultural field. So, this is as salt pans which people very commonly do for the producing the salt. So, there is all black patches which you see here is the sand bowls which developed at the time of during the ground shaking and the why this patch are from the photograph which was taken after the 1811.

Now, this 2 earthquakes we have been con compared because till date we consider that the Kutch region is the region of stable continental a region where which is sitting away from the seismically most seismically active zone like Himalayas.

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This were these sand blows as I was talking on that day that this typically resembles I have volcanic cone and then along with that we also see a formation of longitudinal fissures and this fissures were also instrumental in pouring out the liquefiable sand, as well as water which was present close to the surface.

You can see the wide fractures or the fissures which were been formed they were full of water full of water.

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So, the terrain of greater half cutch is very hostile and very flat region mostly you do not see the anything in this region except the small bushes which are which are growing otherwise and it is completely flat terrain comprised of very fine tidal deposits, this road is of course, recently constructed mainly for the moment of BSF Jawans.

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And this is the pictures from great Rann of Kutch.

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And in some locations where we do not have road we need to move on the marshy land.

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So, this picture if you see I put myself is an scale to show the dimension of the sand blow. So, this is the a sand blow which was before this be like before the excavation we were not aware whether this is an sand blow or not, but as I was showing one of one picture that from Gandhidham new Madrid where we were able to see some white patches or the white dots. So, this is very much similar to that so, there is an difference between the color of this surface and the sand which is sitting here.

So, that what prompted us that most likely this is an sand blow and the recent event which was triggered was 2001. So, this field we did then 2005 and 6 where we encountered this features. So, this is close to the Allah Bund epicentral area. So finally, what we decided that if really this is in sand blow then we should see some liquefaction features.

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Hence, we started digging at some locations and of the same sand blow.

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And what we found was a beautiful contact between the surface or the topsoil or the cerumen succession and the alien sand which is which came from below. So, you can see the dimension is quite wide and that resulted into the pouring out of this whole sand boil which we or the sand blow which we have seen it is more than 2 meters in diameter. So, this was not the only one conduit or the dyke through which the sand was poured on the surface because of the increase in pore water pressure. So, you please remember what we discussed in the previous lecture that the ideal conditions for triggering the liquefaction is the cohesion cohesive less sediments one.

So, what we decided that to dig and this was the exciting moment for us to see now the alien sand having contact with the near surface succession. So, this sand is definitely which has which came up from subsurface. So, if we just put this sketch here of this section what we see is that.

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We have the horizontally laminated succession which is definitely in tidal succession we have and then the sand which is sitting here is something like that ok. So, this sand is probably coming from, but not probably we can say that this is coming from some selves subsurface this I am sitting here and this whole area is your tidal sediments. So, this was one important finding which we saw and this is good for the understanding that what exactly happened during the liquefaction.

Apart from what we used to see in the textbook. So, what we need to have the ideal conditions for this as one as we need to have a the cohesive less the sediments and b water saturated. So, this is two very important points which we need to keep in mind. And of course, another important point which I will come later is the overburden. This is again an important point that is the overburden which, but what I am talking about is the suppose we have the non liquefiable layer either this clay and then we have a liquefiable layer here and maybe it is also sitting on the top of the and liquefiable layer.

So, if this is a section we have and this portion is water saturated, then chances increases of having the liquefaction, but at the same time if the thickness of this is large with a greater than the suppose we put this in an H 1 and this is H 2. So, if the thickness of H 1 is greater than H 2 then in that case the liquefaction chances become little bigger. So, if H 1 thickness is greater than H 2 because it will not be able to break this unit in that case so, this we will talk later. So, let us see few more examples from the great Rann of Kutch how it looks like.

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So, this is a section so, this portion which you see is the plan view now man and the horizontally and this is the vertical section. So, you see in big from this is the conduit which is coming up and then getting up vertically here. So, very huge sand of blow which is which was been observed here and this is the contact between the laminated sequence here which I was showing in the previous one and the sand we just is a pure

sand which is which has been poured out on the surface definitely this also indicate that there is this is all riverine deposit or the floodplain deposit which was deposited by then existing mighty rivers.

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There is another picture of the same trench. So, where you can see the contact in horizontal on the flat surface and in vertical surface over here so, very thick sand which was been poor.

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So, what we found was so, this was not only the one sand blow we were having multiple sand blows which we have been observed in this particular region. So, as I told that if you have an ideal condition then you can have the liquefaction even at the magnitude of 5.5, but the shape or the size of the sand blows itself indicate that the magnitude was much higher than 5.5 ok

So, there is another relationship and the studies which have been done which also tells about that what will be the size or the dimension of the liquefaction structures or the features depending on the magnitude, that is another point which is important.

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Now, before I go to the further detail one important point which I would like to mention here that this area because it is absolutely no habitation no one stays here because of it is hostile condition and the completely flat area, no damage or it will if there was no hazard because of the delayed fraction here, but if similar terrain is there where we have thick population or the area is thickly populated then this phenomena or the process is a matter of flurry.

So, what we did was another typical excise we collected the samples from the sand blows and we are planning to date the samples which will tell us that when exactly this liquefaction took place and of course, the date will be close to 2001.

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Another feature which we found was gain and very interesting one that we saw a sharpened mole track and then initially we thought that this is an insect burrow or some animal which travelled through this might have created this burrows and all that, but this was we were able to see such fine cracks and then raised up land here or the material along this line 4 kilometers.

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Then we decided why not to have the see the section and then what we did was that we open up a very small trench which clearly indicated that does not feature related to the

sand dykes. So, the previous one which I was showing was sand blow at a feature which we saw was circular and in some areas I was showing the photographs which was been taken something like this and then at the centre we were having the cone the typical cone structure so, this is another. So, sand blows, but this one is our the dykes security.

So, an interesting thing which we found was that these dykes showed us and fragments which had been broken from this side.

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So, close up of that if you see here what we see is this is the contact between the laminated sequence here, pure sand coming here and then in between this within the compute we have some broken fragment.

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Close up of that if you see is this one here. So, these are some broken fragments of the soil the capping soils. So, these are all disoriented I am talking disoriented in the sense if you see here we see the laminations which I have seen almost horizontal over here.

So, these are all disoriented fragments broken fragments which were been carried within the dyke when the there was on sand moment. So, there is an typical example to flue also to show that this was this material that is a sand is they came up from the surface or from the unit which was sitting far below from the from the surface and they broke the overlying units.

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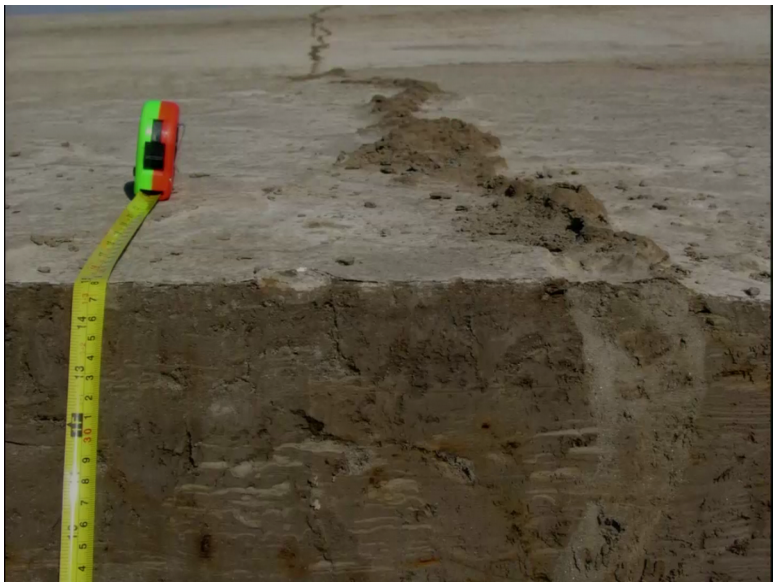

There is another example from the same crunch which clearly shows the disoriented fragments.

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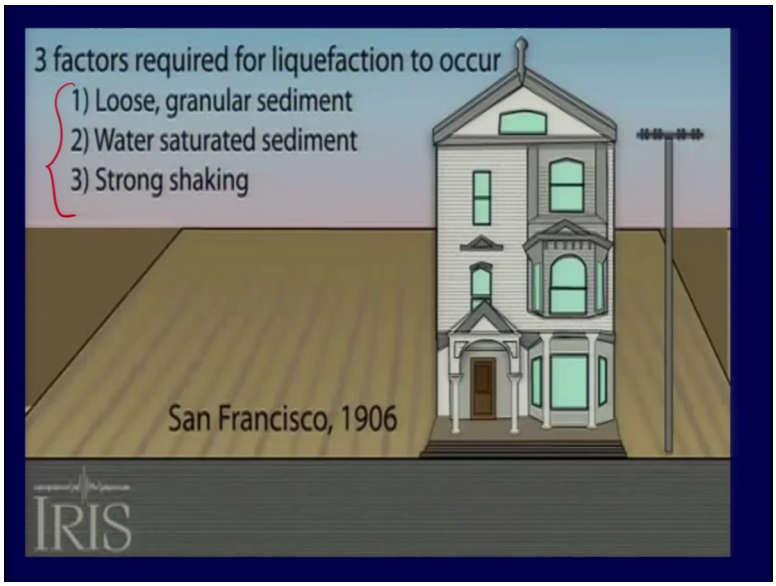

Now, the factors which I was talking apart from the strong ground shaking so, one you have the ground shaking because of the earthquake, second is the water saturated sediments and water saturated sediments should be near surface. But of course, we also talked one in one of the other slide in the previous lecture that liquefaction can also take place in the deeper part, but that may not reached right up to the surface. So, it will be it

will die out in form of cells and then we should have cohesion less or cohesive less sediments which are loose granular sediments. So, if you see the basically what happens is.

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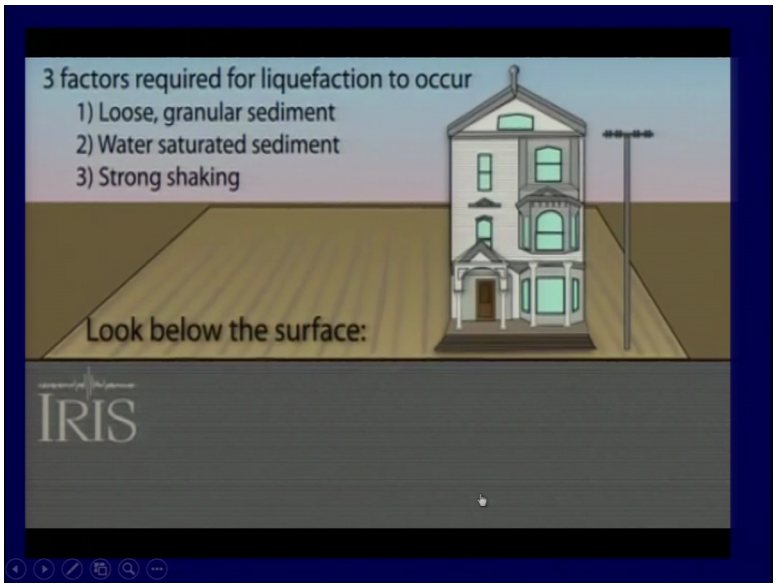

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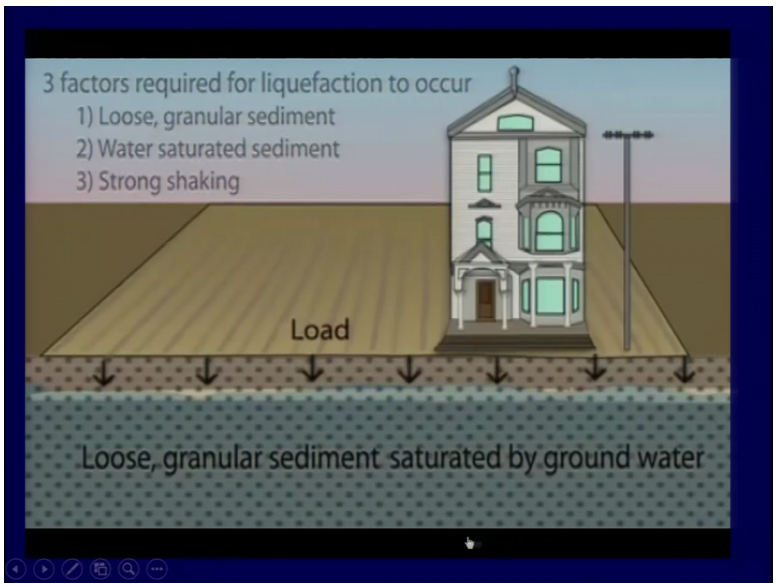

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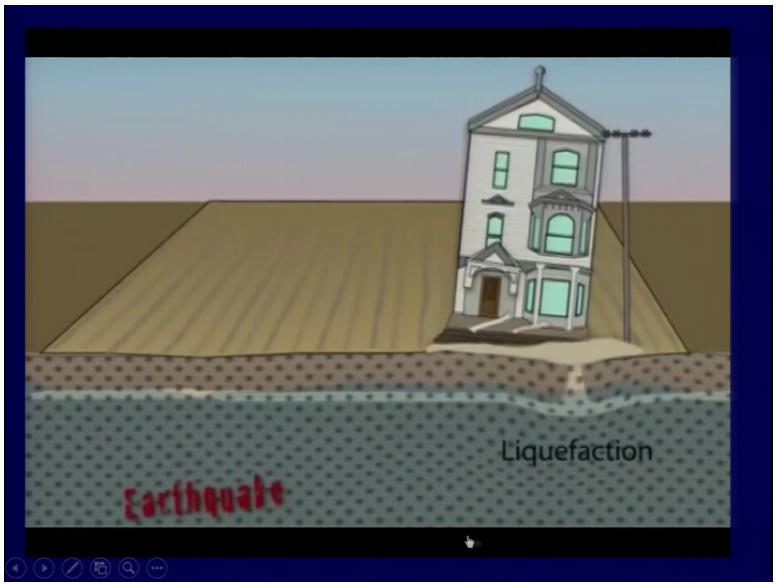

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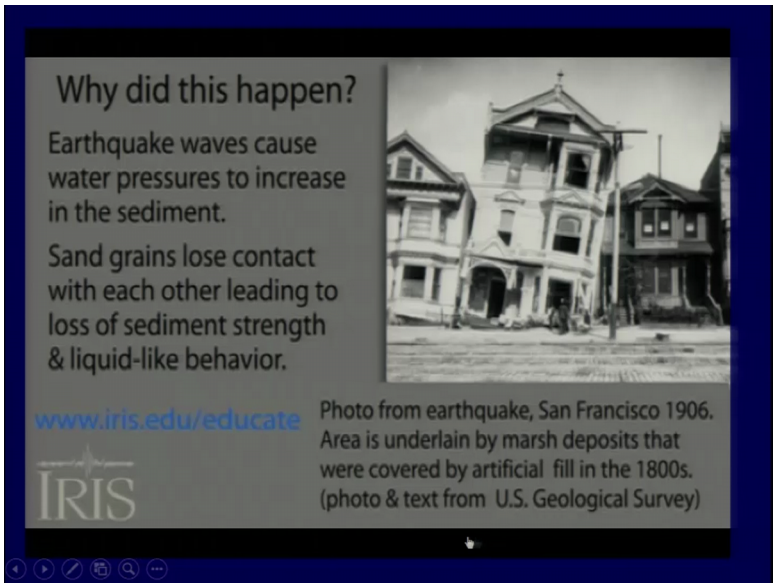

So, this is the photograph which was taken after the 1906 San Francisco earthquake and if you watch the movie again you will be able to see that house which has been shown here in the sketch. So, basically what these are the 3 factors which we are then we have listed here are important. So, you need to have an very strong ground shaking, but there is an ideal condition for the liquefaction loose granular sediments and water saturated sediments. So, as soon as the pore water pressure increases it will result into the loss of shear strength of the cohesion cohesiveness sediments which will result into the phenomenon of liquefaction.

Thank you so much.