Natural Hazards
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Lecture – 20
Ground Effects and Evaluation of Earthquake Hazards Part II

So, welcome back as.

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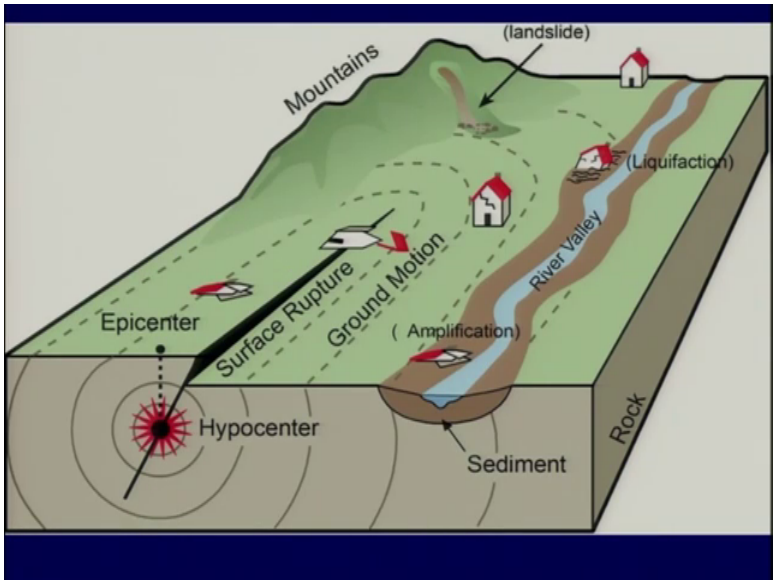

So, in the previous slide and the short movie what you see is that we have different material either we can say the different sites. One was rocky, another was softer elements and then we are having an water saturated sediments. So, effect of the seismic wave which is passed which pass through this area rocky soft and water saturated so, they will behave differently and the amplification the effect of that seismic wave will be different at different point of form point.

Now in the previous lecture which I was showing that you how why it is so important to map the active fault on the surface. That is the surface ruptured is that without having the understanding, one should not put the house right on the top of the default scrap all the default fall time otherwise you can experience and total damage if there is in rapture.

Of course in the epicenter area the peak ground acceleration will be extremely high, but and along with that if you know the line of surface rupture or the fall time you need to

avoid putting your structure on top of that. So, amplification will vary from place to place and as we were talking about that if you have the loose sediments mostly closer to the river valleys or the alluvial plains or the flood plains you may experience a severe liquefaction phenomena.

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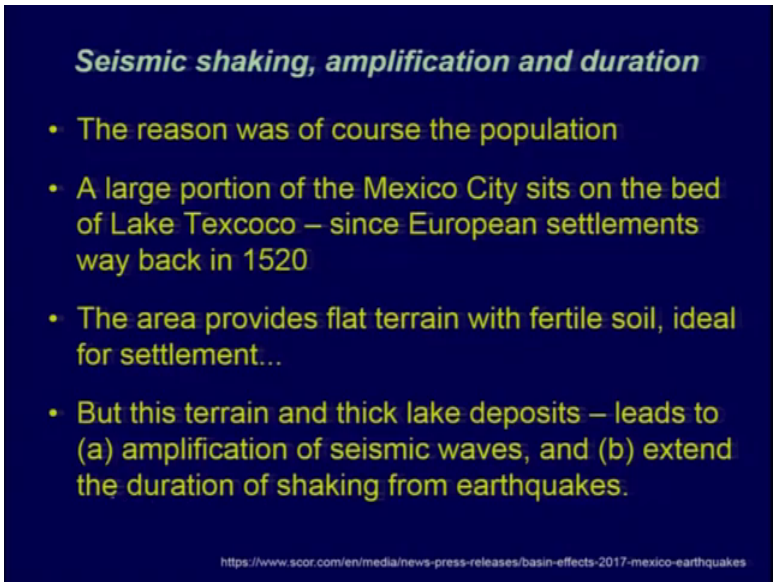

So, seismic shaking amplification and duration this is an example from Mexico. The concern was mostly about the population, because most of the populations the settlements we will come across, we will be in the alluvial plains because of several reasons for the water resource and also for the fertile land and all that. So, large portion of the Mexican city sets on the bed of lake Texcoco - since European settlements way back in 1520 AD. The area provides flat terrain this is one reason which I was talking; fertile soil ideal for the settlement.

So, any settlement even if you go back and try to look at the Indus valley civilization most of the sites where along the adjacent to the riverbed and this is one of the reason. Even today you will see brief thick population is in the indo genetic plain because of the flat terrain fertile, land water is easily available. So, people of course, have more try to settle down in such areas. But this terrain and thick lake deposit lead to one amplification of the seismic wave and extended the duration of this seismic shaking from the earthquakes.

So, this is another added problems which we will experience and usually people experience if they are in the alluvial plain areas. So, we will one will be amplification, second because of the amplification you will see more than duration of the shaking we will increase.

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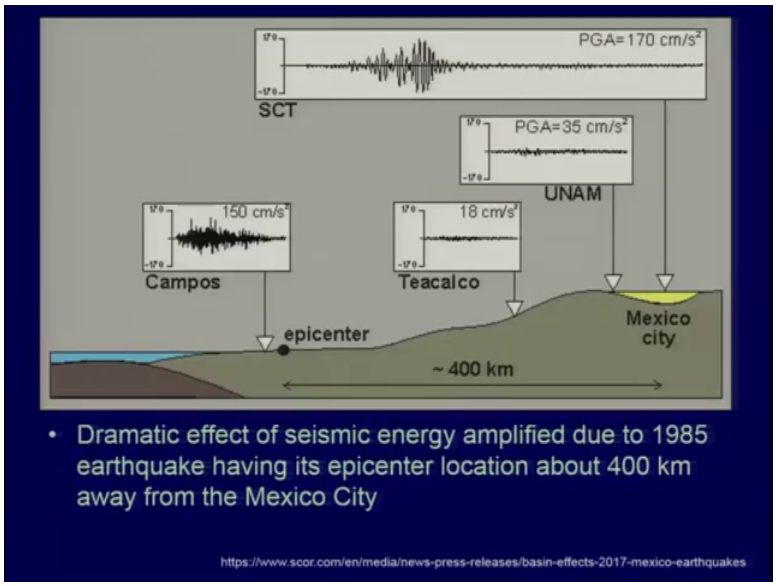

So, this example if you look at from the effect of seismic energy amplified due to 1985 earthquake. Having its epicenter located about 400 kilometer away from the Mexican city. So, Mexican city is located here and this is an schematic diagram the earthquake was triggered somewhere here epicenter which was almost 400 kilometer. So, what would have been expected is that in the epicenter area maximum damage was not fluid have occurred and the duration would have been larger here, but that did not happen. The amplification was comparatively higher 400 kilometers in the away from the epicenter area that is in the Mexican city.

And the reason was what we were talking about in the previous one that the whole city or the settlement is sitting on the lake deposit and the duration was also much much higher as compared to what was experienced in the epicenter area. Where as in between in some regions the peak ground expression was comparatively lesser, but even of 400 kilometers the peak ground acceleration was much much higher.

So, the important part is how far we are sitting will be one criteria of course, but what are the deposits underlying deposit that will be the most important parameter one should

understand. So, if you are sitting on the hard rock of course, you are to some extent safe you will not experience the amplification, but if you are sitting on softer material or you are buildings such sitting on the softer material. Even though you are sitting away from the epicenter area, you are bound to experience peak ground acceleration will be much much higher.

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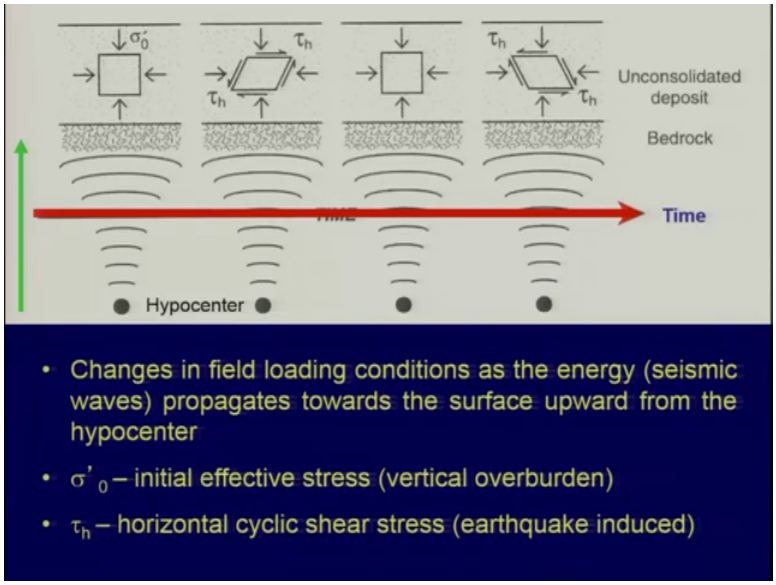

Now this is another example which we will clear your understanding about the seismic shaking. So, change in the field loading conditions as the energy that is an seismic wave propagates towards the surface upward from the hypocenter. It changes and slowly what happens is that over the time, you will have the deformation because of the cyclic stress.

So, this will go back and forth, back and forth and that will result into your increase in pore water pressure complete compaction of the water saturated deposits or the material. Now here rho prime is your or sigma prime is your initial effective stress, vertical overburden and tau is your horizontal cyclic shear stress. So, if duration is much higher, then the effect will be much much higher.

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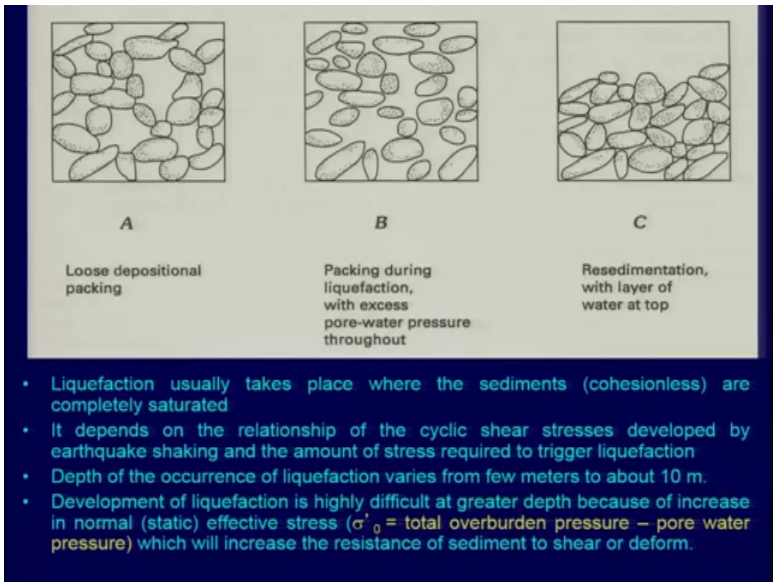

So, loosely packed deposits will have larger pores filled up with water, but yes of course, this should be water saturated. If it is not water saturated, then chances are less to enter into the liquefaction phenomena. So, near the surface if you are having un liquefied layers like clay and then or these will define salty sand, but 2 meters you are having porous deposits like sand cohesion less saturated with water that will result into the liquefaction.

So, liquefaction usually take place where the sediments are cohesion less are completely saturated. It depends on the relationship of the cyclic shear stresses developed by earthquake shaking and the amount of stress required to trigger the liquefaction. Depth of the occurrence of liquefaction varies from few meters up to tens of meters.

But below this up to 10 meter if you are having like chances are bit less, but of course, you will have the liquefaction will not reach right up to the surface. It will within the subsurface layers because of the overburden, but below that you will not be able to experience much of the liquefaction. Development of liquefaction is highly difficult at greater depth the reason is because of increase in normal static effective stress which will increase the resistance of the sediments to share or deform because it will be difficult to shear the material which is sitting at the greater depth.

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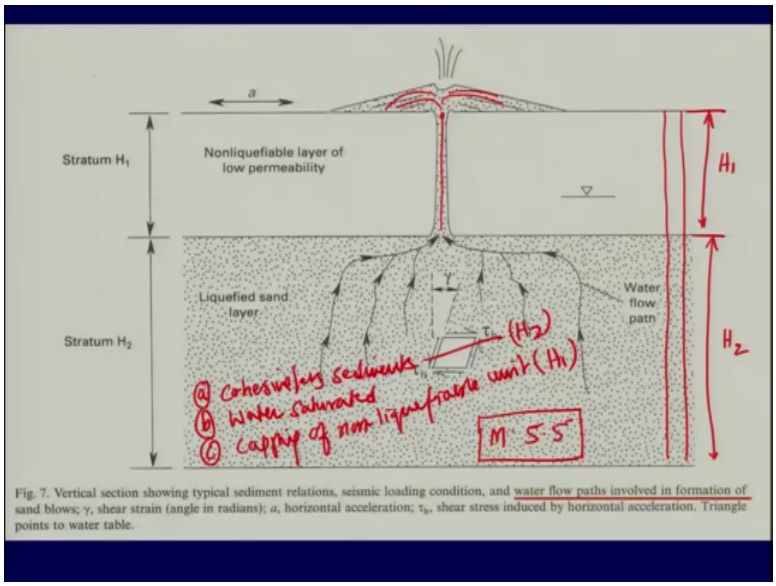

So, what we see here is this schematic diagram which talks about the non liquefiable layer with low permeability and this is on porous layer or the liquefied layer mostly the cohesion less sent, but water saturated. So, when the cyclic shear effect the sediment package here, we will result into increase in pore water pressure and this liquefied material will be poured out through either through conduit in a form of a sand layer and this phenomena is very much similar to what we see in the volcanic eruptions..

Now some time it has been also seen because for if we need to do the seismic micros donation and then we try to take number of boreholes and then we study the stratigraphy. And we also try to understand that how thick is this unit that is the unit which is will be prone to liquefaction and which is a non liquefiable unit. So, this is your H 1 and this is your H 2. So, this also we will be if this is very thick, then you need more of the peak ground acceleration to break this unit

If this is thin then even with the lesser ground shaking, you will be able to experience the liquefaction and the threshold limit to trigger the liquefaction is within the earthquake of magnitude 5.5 if you have ok, then it is quite likely that you will experience a liquefaction. If a site is idle then idle site is what we have discussed this that we should have an like a cohesive less sediments, b you have like water saturated and then c you should have an capping of non liquefiable unit that is a H 1 and this one will be your H 2.

So, this is an ideal condition which we should have and even with the magnitude of 5.5, you will be able to trigger the liquefaction.

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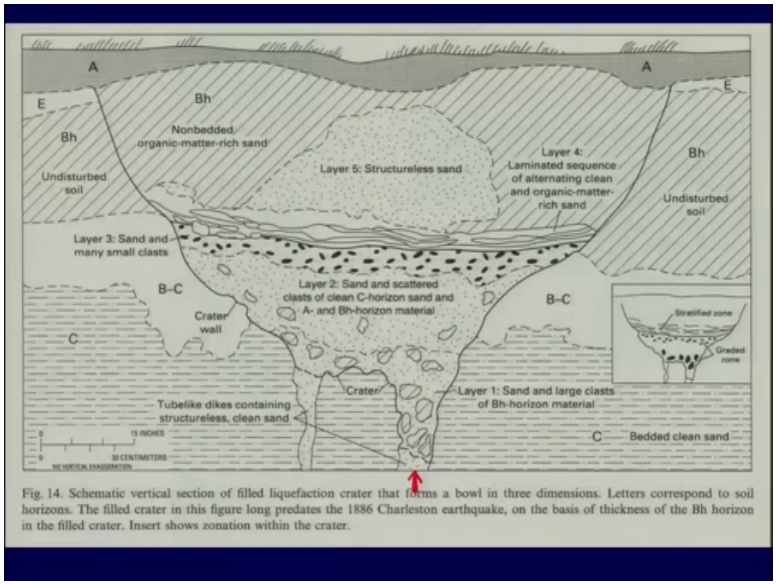

Fig. 14. Schematic vertical section of filled liquefaction crater that forms a bowl in three dimensions. Letters correspond to soil horizons. The filled crater in this figure long predates the 1886 Charleston earthquake, on the basis of thickness of the Bh horizon in the filled crater. Insert shows zonation within the crater.

These are a few examples which talks about that how the value liquefaction or the liquefaction which took place or triggered by the pre previous earthquakes we will look like. So, this is an again a section as we were looking at the sections of faulting events or the ruptures along the active fault. This is the similar to that, but this is for liquefaction. Now these are the craters which have been formed and these are the connote which broke this units and they have they have brought the material from subsurface.

And when such depressions are been created on the surface because of the strong ground shaking and some point of time you see also the deposition which is thing deposited in the depression; so, material will come into the depression and will get deposited. But one interesting thing which you should mark here is that when the liquefy the material with the high pore pressure moves up through the conduit it breaks, this unit because it is coming up here.

So, what you see here is the broken disoriented fragments of layer 1 or sorry that the unit c. So, in this you the broken fragments are been seen disoriented. So, this we say the rip up class ok. So, we are having class which have been broken from the overlying units when the material or the liquefiable material is moving towards the surface. This also

helps us in identifying that this conduit is the feeder type for the or the feeder conduit for the liquefiable material coming right up to the surface.

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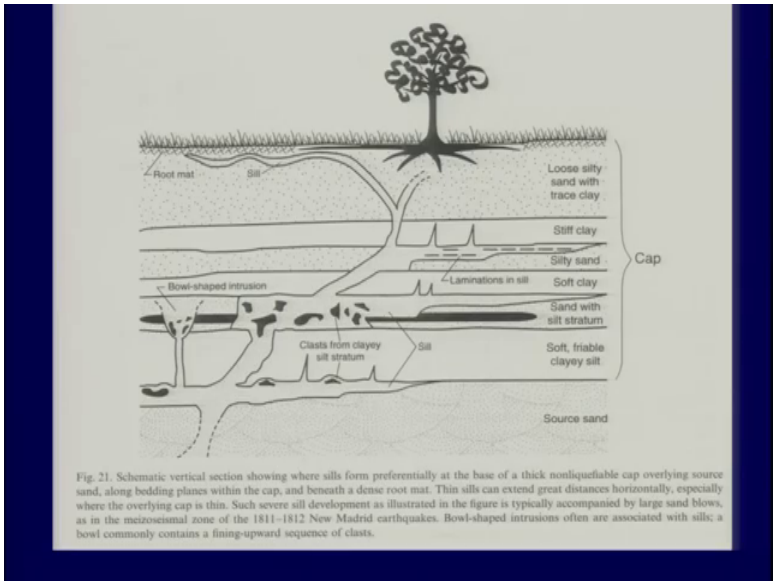

Even if you are having the liquefaction taken taking place in the deeper part and they may not reach right up to the surface, but they are die out getting liquefied material right like it is it gets along the these sedimentary layers which we call cells.

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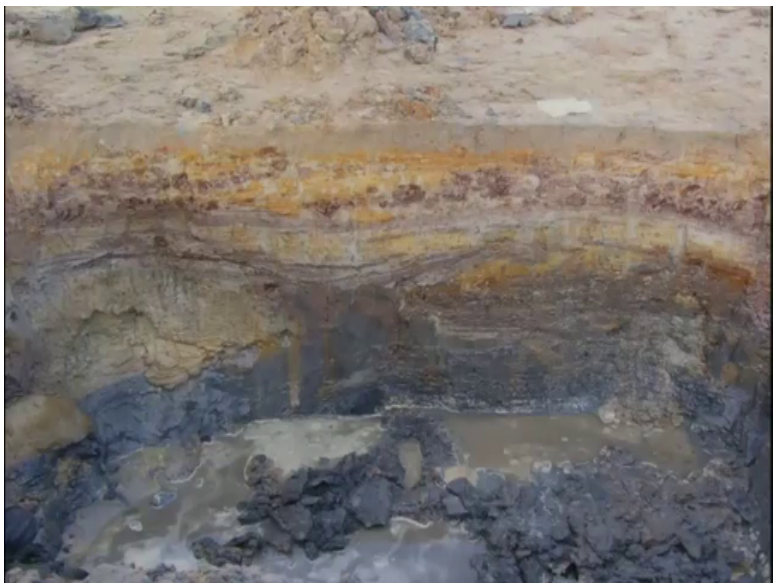

So, this is an example for liquefaction from Andaman where you can I will showing one slide.

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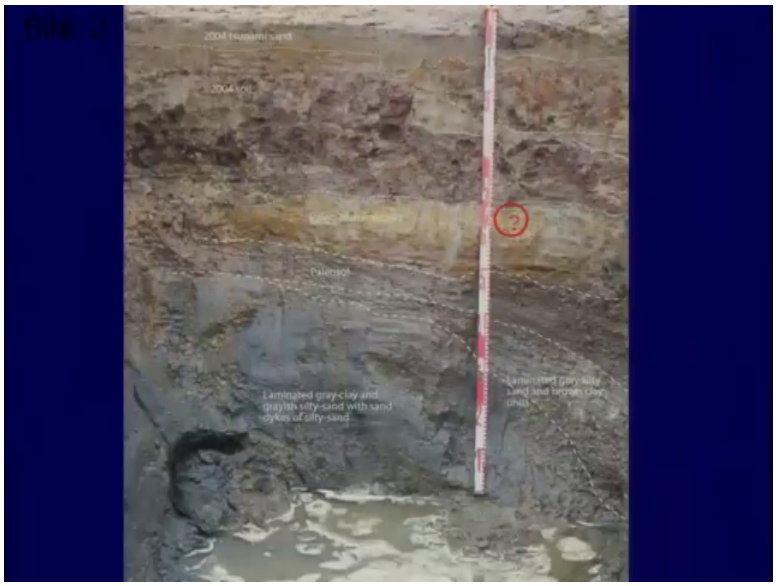

So, we expose the ceriman succession in Andaman after 2001, 2004. So, Andaman earthquake and looking for the tsunami deposits what we came across very beautiful liquefaction features also.

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So, here you see the class sitting in this clay bed. So, this one class which I was showing its similar to the conduits and this one type which is coming up very beautiful one. So, this is the source unit and this is a conduit which is coming up in and depositing.

So, these is an very small scale crater and over the sand blow which was been formed because of the previous earthquake, but this was not related to 2004 Sumatra Andaman. But this is an older event by older earthquake which resulted into or cause the liquefaction in this region.

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Similarly, you can see the class here of this same clay bed and this is the sandwich was been poured out because of these strong ground shaking. Again this is not related to the 2004, but in the previous large magnitude earthquake in this region.

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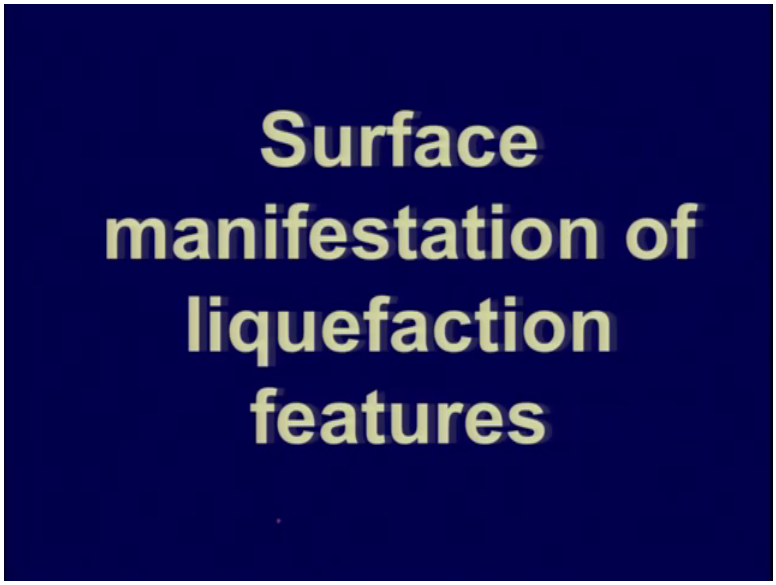

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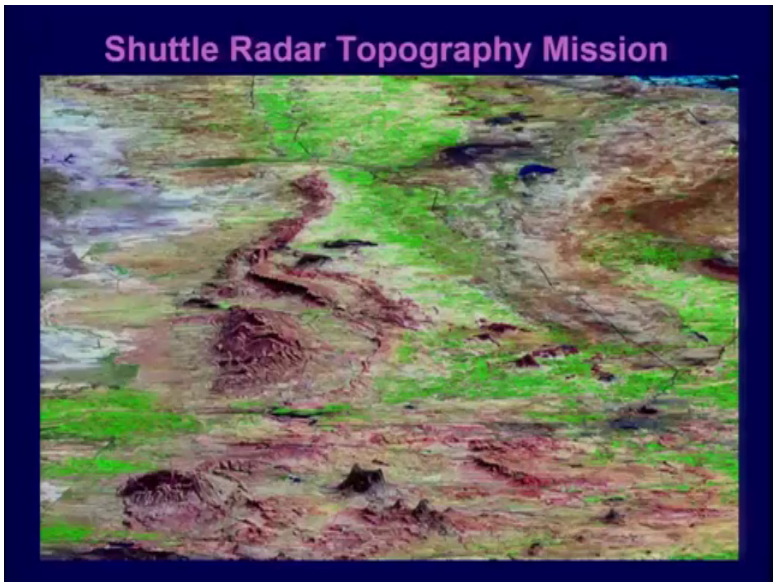

Surface manifestation of liquefaction features what we saw from the settle radar topographic mission data in just after the 2001, Bhuj earthquake. In most of the areas which was water saturated or near surface water saturated sediments were available or the units were available. We saw that the water was been poured out in the great run of Kutchh and many people started talking about that the ancient dried web of Saraswathi is now revived because of this water coming right up to the surface.

But this was in temporary phenomena, this was not impermanent phenomena. And as I discussed that there will be in strong ground shaking and the material the porous material which are saturated I will get will be compacted and because of the high pour water pressure the water will be almost ejected out on the surface.

So, I will stop here and we will continue in the next lecture, trying to see more signatures of the liquefaction. And as I told that this is very important part of course, we need to know that what type of material on which our construction has been done and how far we are sitting from the resource.

Thank you so much.