Natural Hazards
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Lecture – 19
Ground Effects and Evaluation of Earthquake Hazards Part I

Welcome back. So, in last lecture, we were talking about that how the folds are formed, and how we see the interlinking of the fold, two folds to give rise to an larger anticlinal fold.

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And as I was talking about on that day that this was one of the best site, which we identified for trenching to see the ancient signature of the ancient earthquakes. So, this is an tip of an plunging anticline, which is moving in this direction. So, whenever there is in rupture or displacement on this particular fault that is in south wagged fault, then what we envisage is that this will grow further towards the east.

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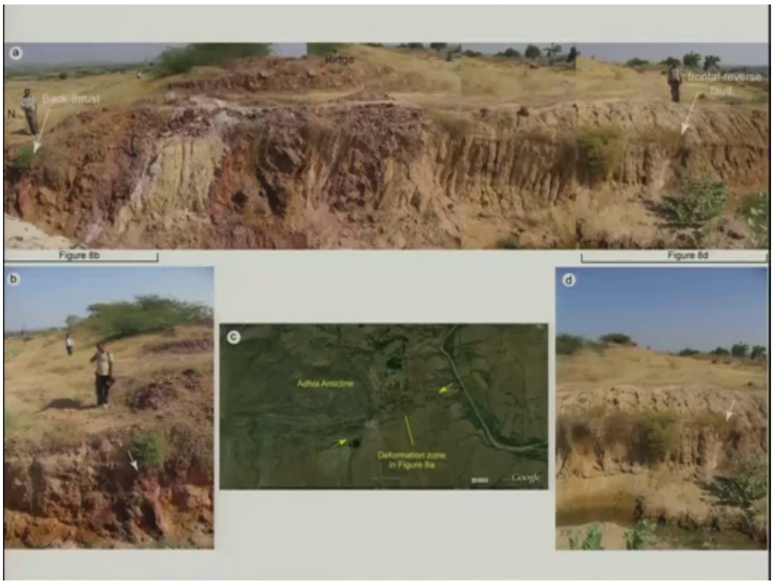

So, we identified as I told that the best place was this notch of the anticline or the nose of the anticline which we said. And then we picked up that if there is a deformation in the coordinator deposits a very young deposits, then that will be helpful for us in picking up the most recent earthquake which has occurred along so south wagged fault at during historic past.

So, fortunately we found and very beautiful artificially cut fold or the ridge, which was been a dug for the irrigation purposes. And we found a vertically stacked Mesozoic and tertiary rocks, and there is in contact between the tertiary and the quaternary.

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So, we decided to trench in this area. So, this was the panoramic view of the fault scarp, which runs in almost like east west direction, and this fault scarp is facing towards south. So, south facing fault scrap, so close up of that so we identified, and this usually we do what we call to identify the ancient earthquake signatures preserved in the in the stratigraphy, so we that is known as value seismology.

So, we opened up the trench, so this was the area which made marked and selected based on our experience, and we believe that the fault is running somewhere over here that. So, this was and small not very small, but yes of course a pit was open using JCB backhole to look at this section, because this will give us the deformation pattern. If you study the section open here, we will be able to see so far for us, we were very confident that the fault is running somewhere over here.

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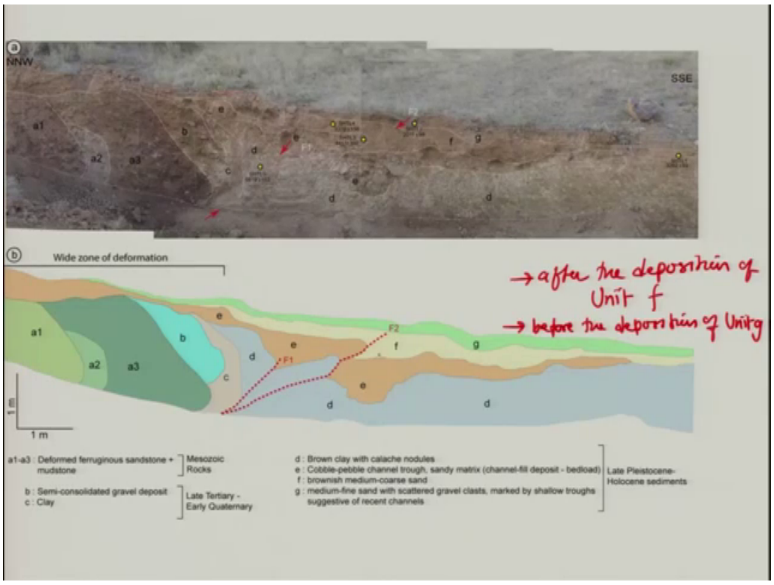

And this was the trench which we opened and steady graph, which we studied. And after the marketing all units, what we see the trench, and this the log of the trench, which shows the deformation or the folding of Mesozoic rocks from like unit a 3. And then you are having the tertiary deposits or the tertiary succession, which also got folded and displaced.

So, this is the faulting which we see in section. So, the f unit was the youngest the belongs to the younger deposits f and g, and the fault which has displaced this over here, it dies out somewhere here. So, what we say that the event the most recent event took place after the deposition of unit f, and before the deposition of unit g. So, we say after the deposition of unit f, and before the deposition of unit g.

Now, why we say this because this was the surface at the time of the earthquake, and which got displaced. So, if this was the surface before the earthquake that means this existed, before the event. So, this already the deposition took place. So, off the event occurred, after the deposition of unit f. And since it is capping this deformed unit f, the deposition of g came up later on.

So, we say the event took place, before the deposition of g took place. So, this gave us a bracket between the now bracket of above of the event actually, so that we will we were able to pick up.

So, this is extremely helpful, and this we suggested here that there will at least two events. And those two events not two, but at least three, but two events were responsible for resulting into an great damage to a Dholavira site that is an Harappan site, which is not very far from this fault. So, these are the interpretation which we made, and based on the value seismic studies.

So, I will stop here, and we will continue in the next lecture what we will talk in the next lecture, we will immediately start that we will talk on the ground deformation, which is extremely important for understanding that what will be the site effect at the time of the earthquake.

Even if the fault is sitting away from the this site, then also we should not underestimate that in terms of the damage that we will not be able to experience the damage. If you are even sitting away from the default, so that we will talk about because the deformation is one part which will take place on default.

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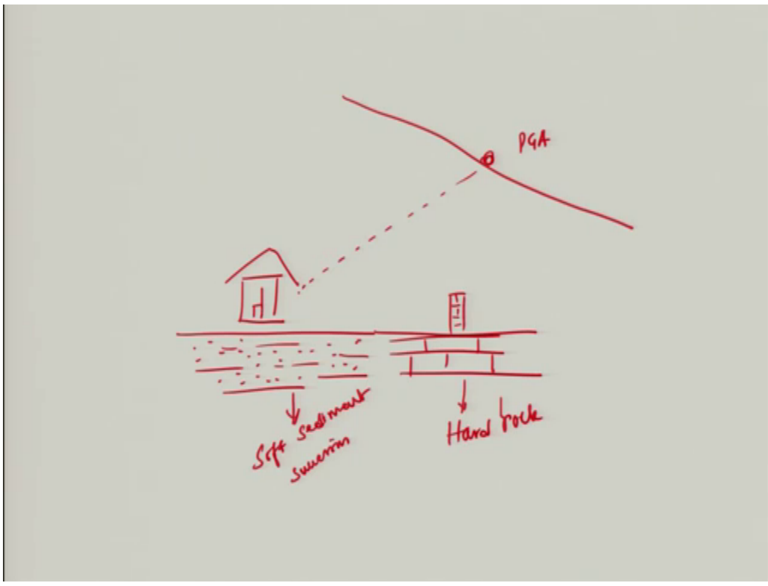

For example, I will just put the sketch here like you are having an fault here, and you are setting somewhere the town is somewhere here ok. So, of course the maximum peak ground acceleration will be at this point, but if you even you are setting away, depending on what is the cerements-1 ok, and depending on that what is the rock type, you are having the deformation or the or the site effect will be different, so that we will discuss in the in the next lecture, what we call the ground effects ok.

So, this we need to take into consideration if you have whether we are your houses or the settlement is sitting on the soft, sediment succession or your houses are or the buildings are sitting on the hard rock. So, this is going to change the scenario how the pattern of damage oh over the time (Refer Time: 08:23).

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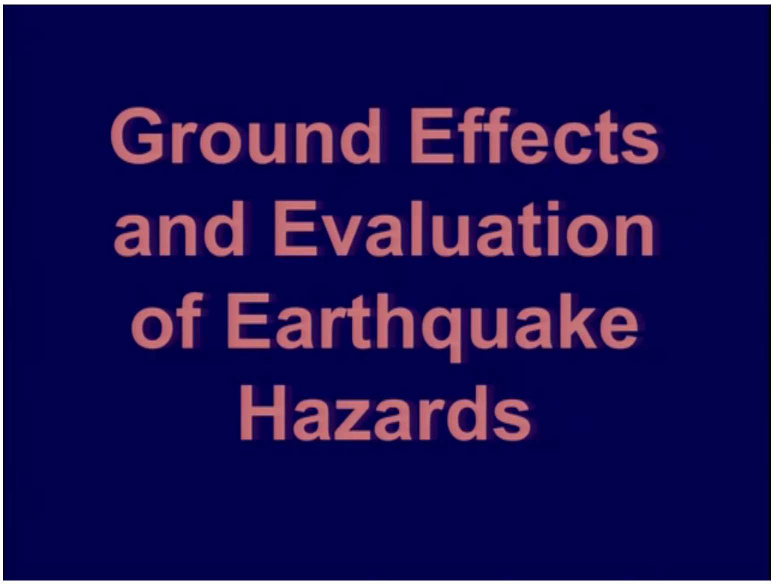

Now, evaluation of the earthquake hazard is extremely important, because as I told in the previous lecture that even if you are sitting away from the epicenteral area, you are bound to get affected because of the seismic waves which are traveling from far distance. So, depending on what are the type of material which your site is located that thing will bother us ok.

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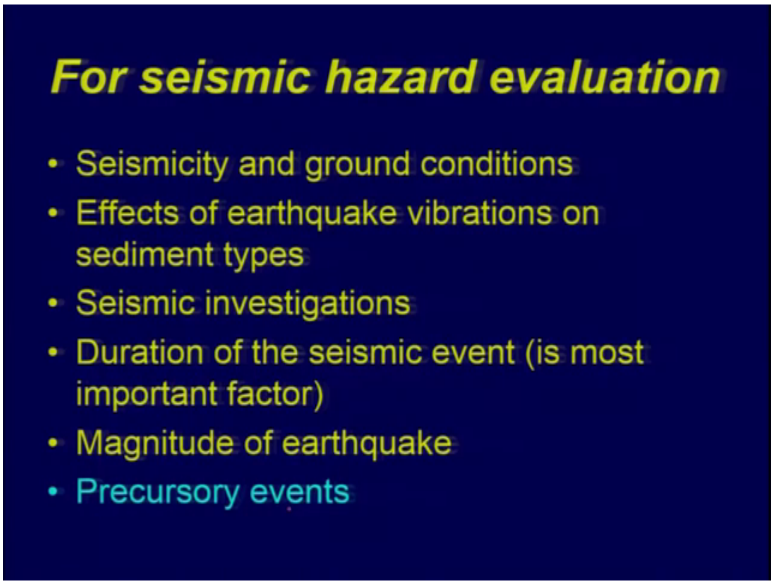

So, for seismic hazard evaluation, mainly what we look at is the seismicity and ground deformation of the area. So, we try to see the historical seismicity, and then ground condition what is the type of material on which, we are putting the foundation of our structure that is extremely important effect of earthquake vibrations on sediment type, because different type of sediments.

Like if you are having sand, if you are having clay or the vibrations, the amplification will be different from place to place. Then we are having seismic investigations, then duration of the seismic event how long this was the event, and how long it is expected, when there will be a next earthquake.

Then magnitude of earthquake is also important, because depending on that where you are your fault is and where the epicenter will be how far you are sitting from the fault line, the magnitude will play an important role in terms of the ground shaking or the intensity of the ground shaking.

And then we also try to look at that what are what are the precursor events, which can help us in identifying or predicting the future earthquake, this is not very much like we did not get and what do you say is that they achieved, we have not achieved fully in terms of the precursor events, because it is very difficult to say or to tell or to pass on the warning that at what time and at the earthquake will occur. But, at least we can we are able to understand, and know that of course this area is prone to earthquake, and what will be the expected magnitude for the next earthquake that is pretty sure for that.

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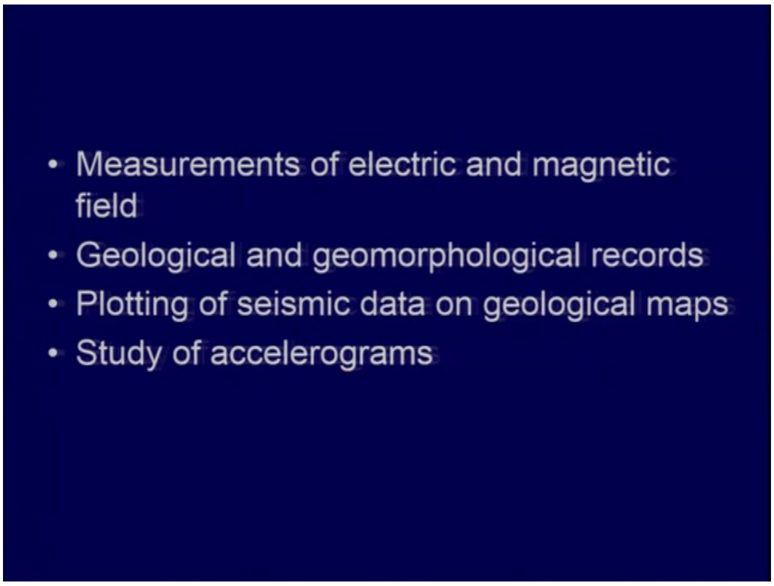

Along with that measurements of electric and magnetic field, people have been working on this, and of course as we have discussed in one of the lectures where we were talking about that magnetic field of the earth and all that. So, when there is an disturbance or the ground shaking or the sudden release of the stored energy, some changes will be observed in terms of the magnetic and electrical field. So, people are doing research on this, and hope in future we will get success looking at such information.

So, geological and geomorphological records this what we are doing, because as I told in the previous lecture, and where we were talking about one of the case history from which in Gujarat, Kachchh around south wagged fault all the formation which have occurred. If the rupture has reached right up to the surface, then they will get preserved in the geological records. And geological records we can say that they will be preserved in the sedimentary records. And geomorphology and the different landforms will be formed, which we say tectonically formed landforms.

Plotting of seismicity data on geological map, this is an preliminary exercise usually we do try to understand that what is the pattern of this seismicity, whether it is aligned along one particular fault or it is diffused seismicity if we see. If it is getting aligned along one particular fault, then there are everyone can say that fine this earthquakes are triggered along this particular fault. And there is an likelihood of having an bigger earthquake in future.

So, and study of accelerogram; so, to evaluate the seismic hazard, seismologist or geophysics they try to look at the seismograph gram or the accelerograms of the previous earthquakes, which can help in terms of understanding that what was the peak ground acceleration at that particular point or the site of interest based on the previous events which have occurred in that particular area, so that can help us in understanding the site effects of the site of interest.

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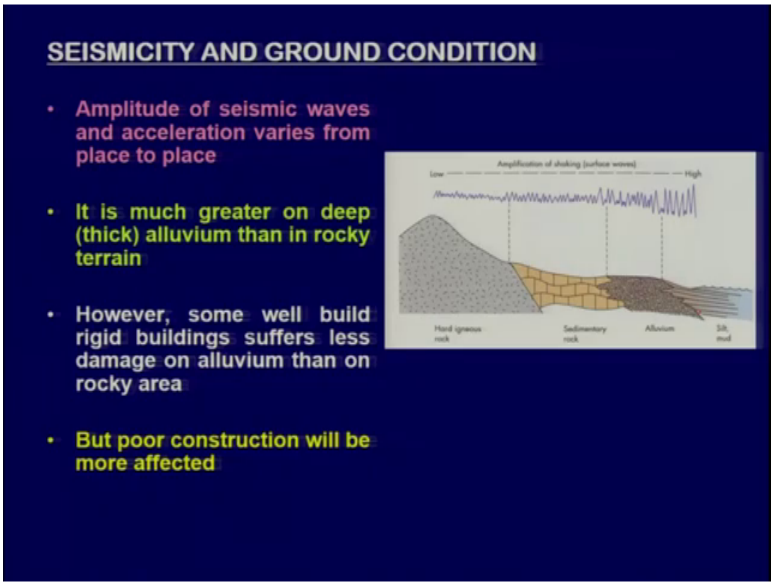

So, seismicity and ground conditions, if we take what we see is that if you are having in suppose in hard rock, and a particular magnitude earthquake has been triggered, then in sedimentary rocks, you will have different amplification. And this will based on the propagation of the surface wave. And in alluvium which is in loose material, the amplification will be little bit higher as compared to the sedimentary rocks. But, as soon as you get into the wave we find deposits silt and mud and all that, then you will have an amplification will be very very high.

So, if you consider this as in Himalayas and this is analogous plane, then one can understand easily or say that this area is going to be affected more, because the amplification will be much higher. So, ground shaking will be much much high as compared to what we will see in the hard rocks ok. Of course, the Himalaya is not purely consist of the hard rock, it all about also have terrain and marine deposits, so we will face something like what we see in the sedimentary rocks.

So, amplitude of seismic waves and acceleration varies from place to place, it is much greater on deep thick alluvial than in the rocky terrain. However, some will build rigid buildings suffer less damage on alluvium than on the rocky ok. So, one has to be extremely careful that they use while doing the construction or coming up of with the structural analysis, they should use the BIS code as a building course, which are assigned for that particular region.

And that is one of the important part, where the geophysicist and even the structural engineers, they study the accelerograms ok, they want to understand that what is what was the peak ground acceleration by and particular earthquake, which has occurred in the past or the recent past in particular fault. But, poor construction will be more affected. And if you if you ask us we would say that most of the construction done in the alluvium in a new kinetic plane is most of the areas villages and small towns, it is poor construction. So, chances of having in greater damage that we cannot ruled out.

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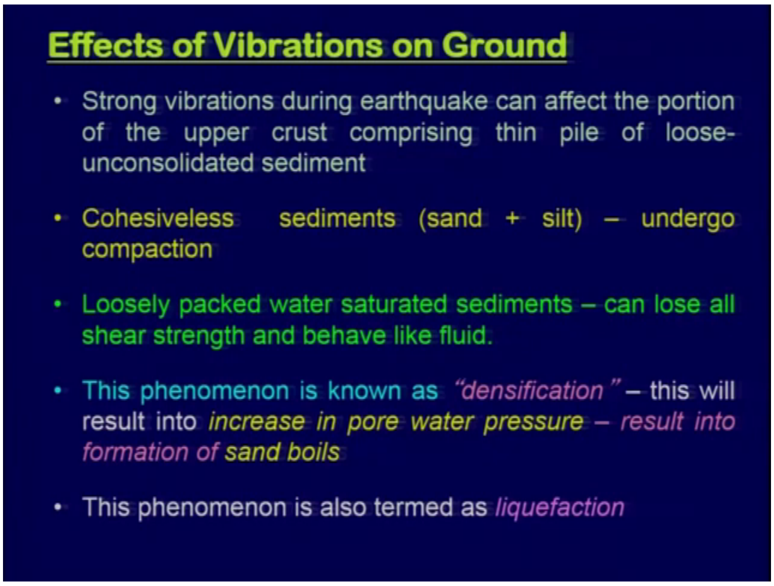

So, effect of vibration on grounds. So, what basically happens is that stronger vibrations during earthquake can affect the portion of the upper crust comprising thin pile of loose-unconsolidated sediments. Now, this cohesiveness sediments mainly sand and silt undergo compaction because of the cyclic stress, they will go under compaction. Loosely packed water saturated sediments can lose all shear strength and behave like liquid. So, as soon as they loses the shear strength, and the structure which is sitting on the top of that surface will collapse.

This phenomena is known as densification. This will result in to increase in pore water pressure which eventually result in to the formation of sand boils. I will show some example of the sand boils from patron of cultch, which we observed during 2001 cultch earthquake and this phenomena is termed as liquefaction.

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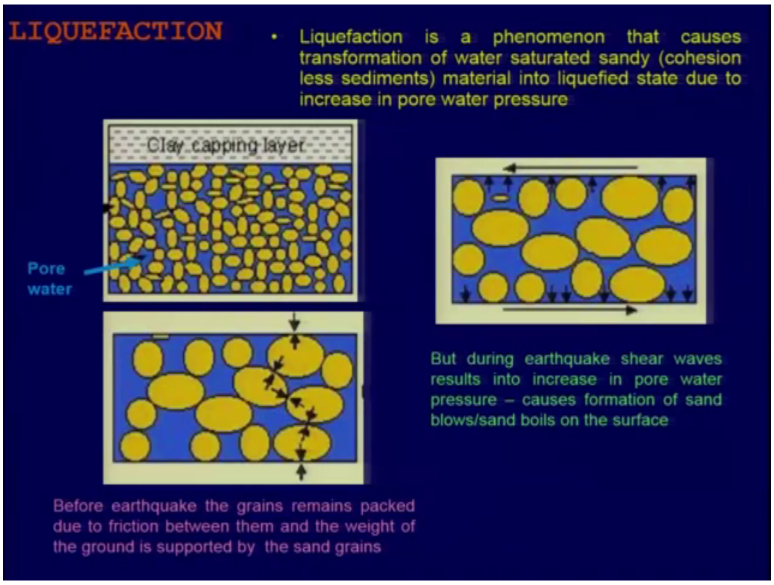

So, for liquefaction what we see here is that we have and uncapping unit, which is not water saturated, which is not porous. As compared to what we are having the porous deposits here, we have a sand. And we are having an very typical bonding nature of the of the sand, and that is an arrangement of the sand grains, and in between the available pores are filled up with water.

So, this remains under a typical condition, where there is nothing is happening no, if whatever the over burden you have, but this will not collapse. But, as soon as you shake this ok, so these are the pore pressure, and the pore water. So, before earthquake the grain remains packed due to friction between them, and the weight of the ground is supported by the sand grains. So, this will be taken by the sand grains and all that because of their arrangement.

But, when there is an cyclic stress, because when the seismic wave passes through the such units or the uppermost part of the earth crust, then it will disturbed this arrangement. And that will result into the compaction. So, during earthquake shear wave results into increase in pore water pressure, causing formation of sand boils at the surface.

So, liquefaction is defined as a phenomena that causes transformation of water saturated sandy or salty or you can say cohesion less sediments, it transform the material into liquefied state, due to increase in pore water pressure. And since the pressure is low towards the surface at the very high pour water with higher pressure will move break the surface and come out of the surface.

So, you will see I will show some examples that when there is in compaction here because of the cyclic stress, then this material is been at the top layer is been broken. And then material which is over here because of the compaction and high pour water pressure, it will rise up break this surface and come up, and ejected on to the surface.

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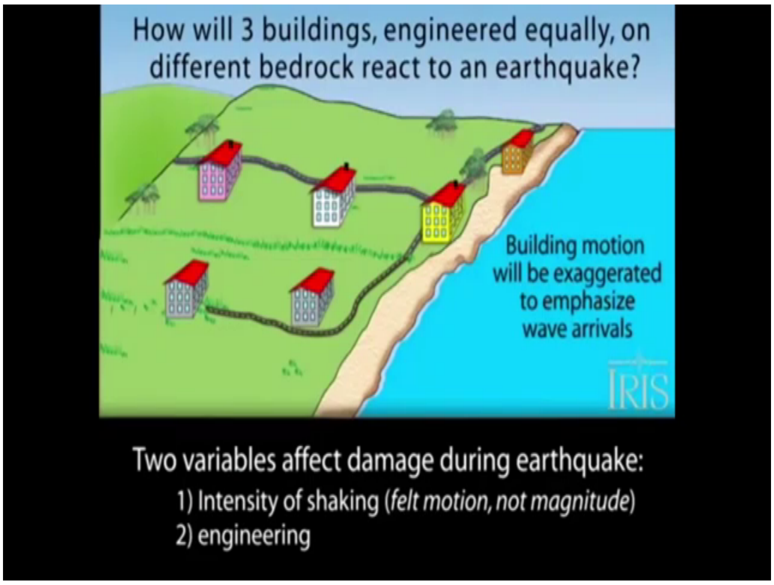

So, this is one short movie which talks about that how will three buildings, engineered equally on different bedrock the react to an earthquake. So, same building with same code, but constructed in three different areas. So, different bedrock how they reacted. So, building motion will be exaggerated to emphasize the wave here it is they have emphasized here, and let us see how what they put it shows ok.

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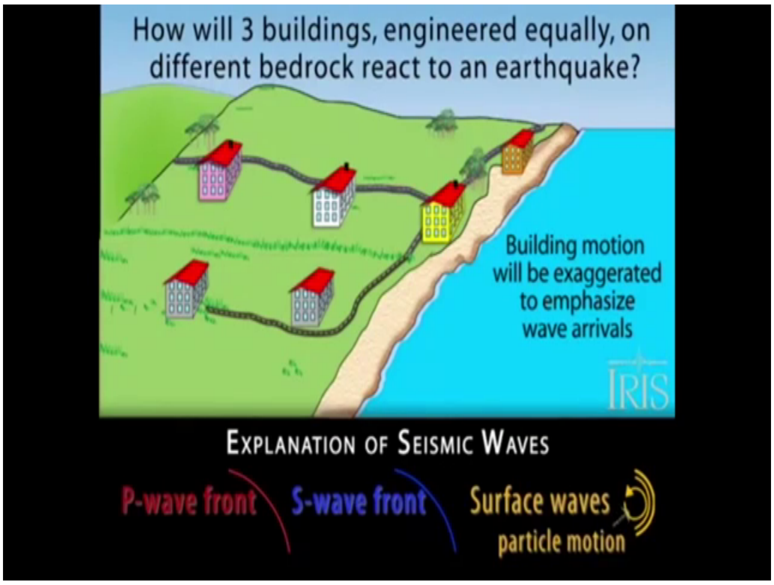

The motion of similar buildings on different bedrock will be exaggerated to show the arrival and compressive P shearing crust, and rolling surface waves from regional earthquake.

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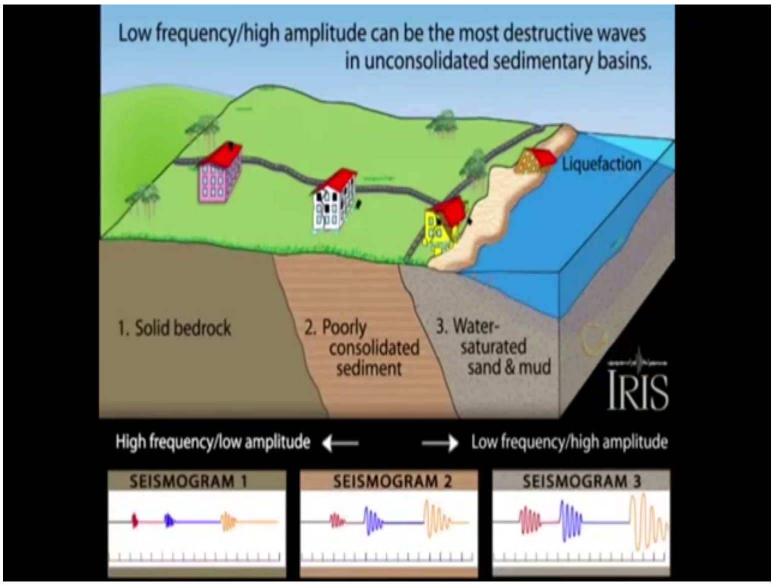

Three consecutive seismograms will show the changing frequency, and amplitude resulting from the change in rock type. The initial P wave arrives with a compressive pump, and rarely causes much damage. Slower shearing S wave introduces a side to side motion that can throw loose objects of floor, and may crack walls. The rolling surface waves are the most damaging and unconsolidated sediment.

As surface waves enter this sedimentary layer, they slow down and increase in size causing buildings to roll. If not engineered for the motion, they can crack and tumble. But, even a well engineered building can sink, during the shaking and liquefaction of underlying wet sediment.

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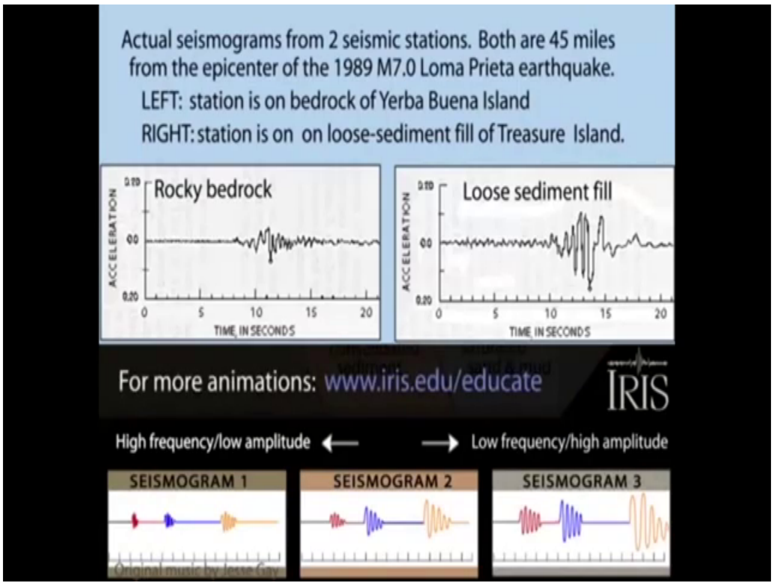

The first seismogram from the pink building on solid ground shows low amplitude, high frequency waves. When the waves hit softer ground they slow down, and increase in amplitude, it is this higher slowing roll that is so destructive during an earthquake.

I will stop here, I will continue in the next lecture.

Thank you so much.