Earth Sciences for Civil Engineering Part-2
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Active faults and its related hazard in India (Part-1)
Module 1
Lecture No 4

Welcome back so in the previous lectures we talked about the various hazards. Now, we will come down to some particular important topics and this is I believe is one of the the extremely important part which all of us should know because the locations of the fault lines in India are not well marked okay and we even we don't have the the historical data or what we call the paleoseismic events, the ancient earthquake data from such fault lines.

So these are some the there are couple of areas which are prone to earthquakes and the most is the most prone is your Himalayas okay so I will I will present couple of um examples from Himalaya but overall I will try to talk about what are active faults and how we identify that and what is, what are the importance of that.

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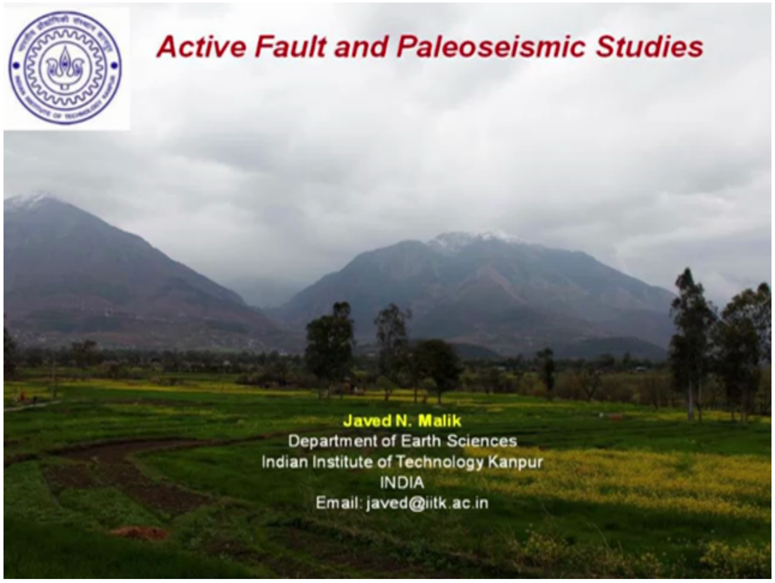

This is beautiful picture which I have taken from the Kangra valley where we we identified recently new fault which extends for almost 60 kilometers and we have named that as Kangra valley fault and that fault was not identified before. And our research or finding suggests that this

Kangra valley fault was responsible for triggering one of the devastating event in Himalayas that was 1905 Kangra earthquake. Let us move ahead.

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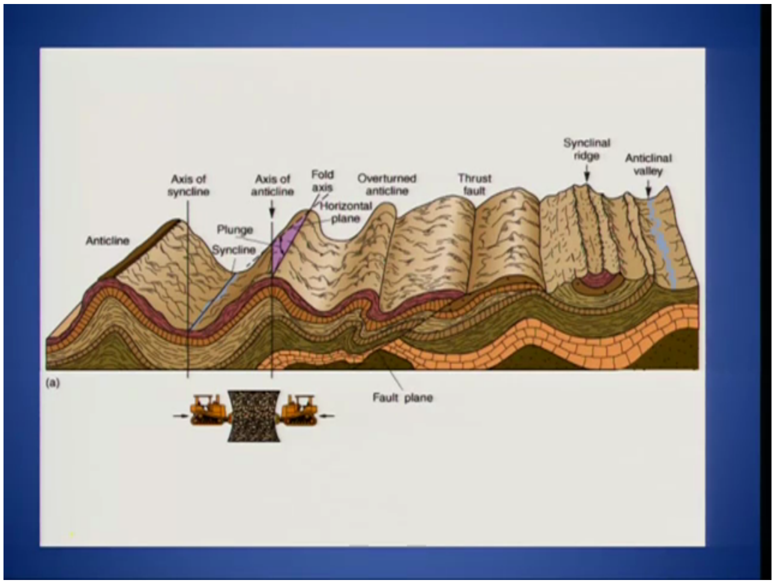

So like what we see in overall deformation this we have discussed in the previous part, part one of this course that if you have the deformation going on then you will that is in the compressional tectonic environment where we are pushing from both the sides the of the plate okay.

Then you will have a deformation of anticlines, you will deformation of synclines which goes by side by side and finally you will have the breakage or the fracture or the displacement of which is above the critical point of the threshold limit, it will deform or it will fracture so this these fractures what we call are the faults okay we will see that what are (differe) we have named it okay. We have if I am not wrong this we have talked in the previous course so but we but we will try to look at the few slides of that okay.

So we have like deformation will result into like if I am talking about the compressional tectonic environment we will have folding and then finally we have fractures or we can say the faults okay so we will have this commonly seen in such environment okay.

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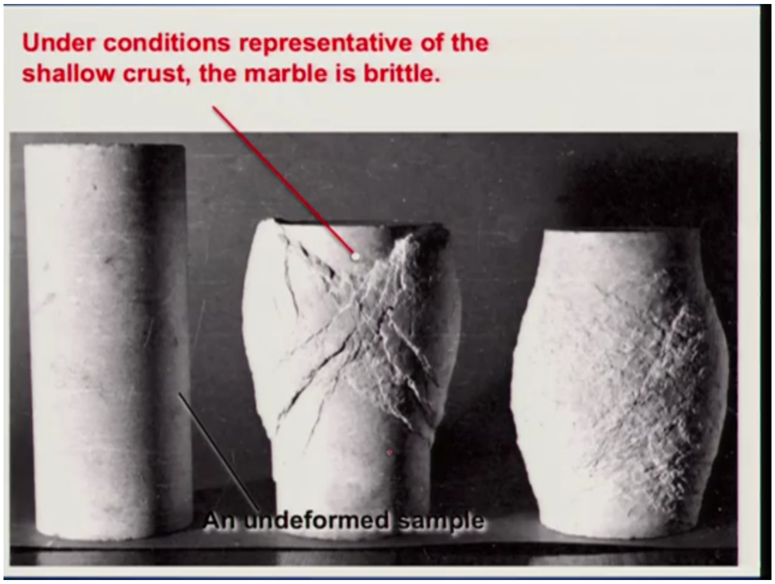

So this is an example which has been given how rocks are formed okay and again the rock will deform differently or it it will behave differently at different level or at different depth within the earth's surface or or within earth interior. Now this is an example of an under formed rock cylinder here, this deformed and this is getting like it is having it is not completely getting fractured okay, why is it happened so, in the next slide, we will talk about.

Now under the different conditions okay because the pressure temperature varies as you move in into the interior of the earth okay so in some conditions, like what we call the shallow part of the earth's crust, if you take a marble, for example there is a marble cylinder okay, a rock rock specimen.

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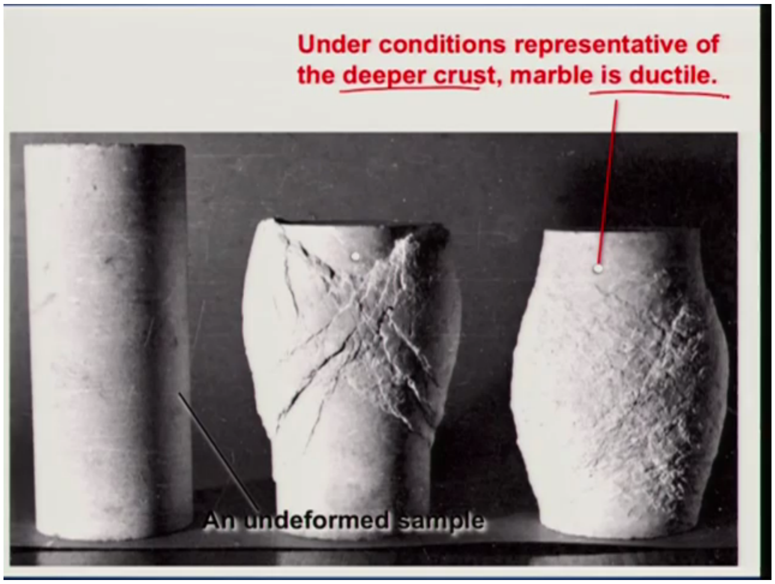

If you deform at a shallow depth okay, the pressure temperature will be different as compared to what you see the greater depth so this will fracture as in a brittle form okay whereas if you deform this in a deeper part okay, a deeper part then it will be ductile okay so it will not fracture. It will just deform okay with minor fractures so these are the variations which one can see and this can help in understanding the the earthquakes which are taking at the the shallower depth, at the greater depth. So the earthquakes which are taking for example at the shallower depth are more dangerous okay because they will result into the fracturing on the surface.

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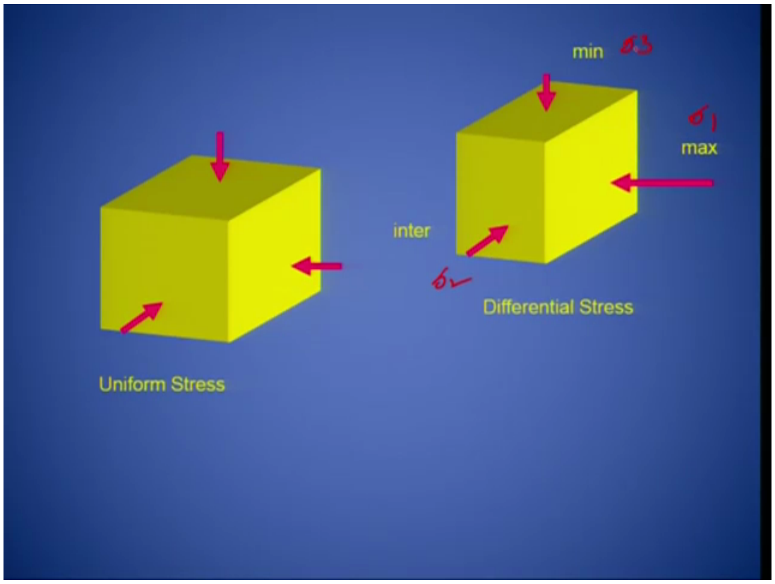

So if you take the deformation in total, okay one we usually see is the uniform stresses which are observed at the greater depth of within the earth interior where as on the close to the surface or in the shallow crust, we have directional stress okay. So if you take sigma 1, sigma 2, sigma 3 then we are having the the direction stress okay so this is your sigma 1, this could be your the the sigma 2 and this is your sigma 3 okay so this you are having different stress okay so depending on that, the the maximum okay then you will have that pattern of deformation or the faulting.

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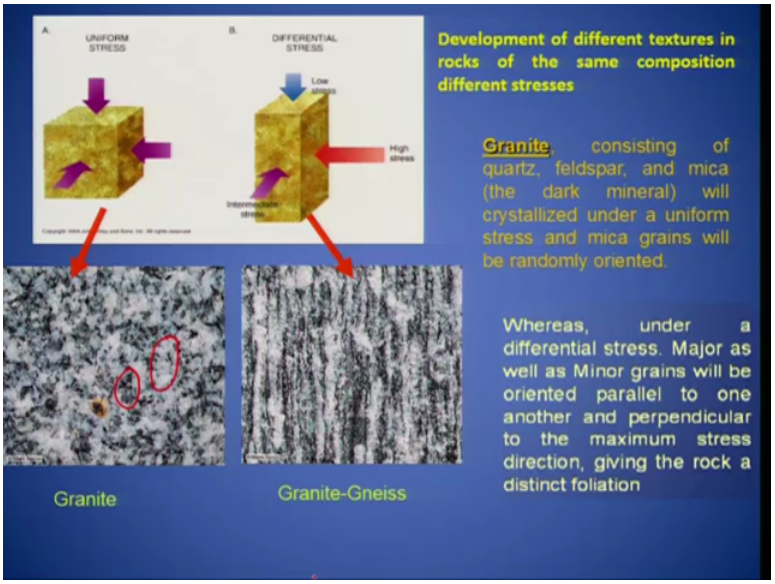

For example if you take rock like in a uniform deformation is there then you will find that all grains okay so you are having this blackish part of the grain, this is the the granite and then we have a quartz and then we have the whitish part is the quartz and all that and where this is the mica and all okay. So if you deform this okay which consists are like the granite consists of (feld) quartz, feldspar and mica with the mica (an) are the are the darker ones okay.

So if you deform this in differential stress okay then this will get preferredly oriented okay. This is what the the rock has changed, this is metamorphic rock (())(7:01), this part we have already covered in the previous course so it will have so under the differential tress you will have the major as well as the grains oriented parallel to the maximum stress okay fine. So this is what we we see.

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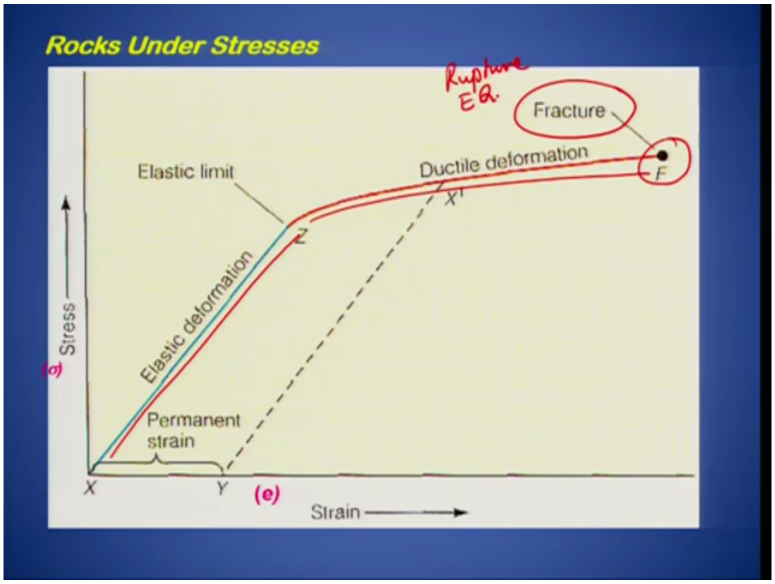

So very simple stress strain relationship if you look at if you keep on increasing the the stress, you will keep building up the strain okay fine. So eventually all material within the earth or at the earth surface are having some plasticity okay so initially it will deform, elastically then you can ductile and then finally you will have the fracturing okay and this fracture what we see is your rupture.

If there is a an sudden displacement then this will result into an earthquake okay so earthquake is a sudden release of the of the energy the energy which has been stored so this what we talked about okay so strain is building up building up along plate boundaries and finally it will be released okay and that release will be in terms of what we see the fracturing or faulting okay so this fracturing for us, we will take this as an faulting.

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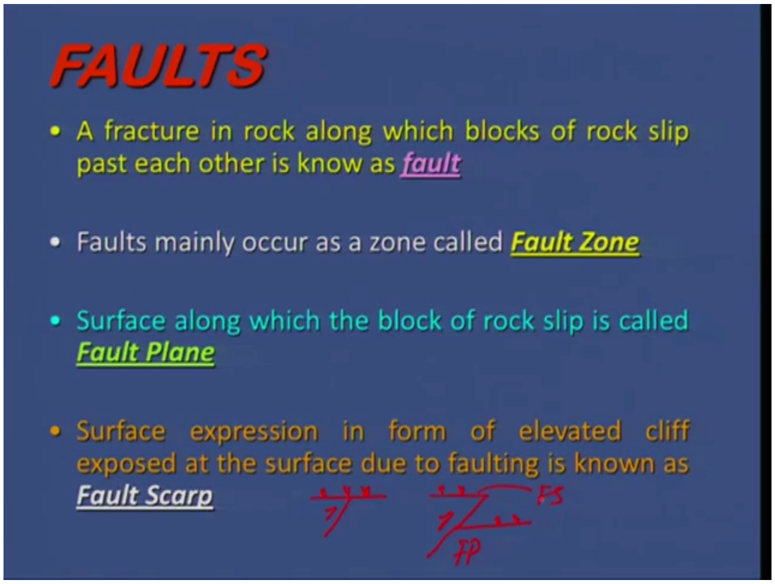

So faults if you look at what we usually define, a fracture in rock along which block of rock slip past each other okay is termed as fault. Of course the question may be asked that there are many such fractures which will show displacement okay, should we call those as faults? We will say yes okay but they are not seismogenic faults okay. If they are not going to trigger any earthquake then we will say they are non seismogenic faults.

They could be related to some deformation, they could be related to some other reasons like subsidence and all that but they are not exactly the deep seated faults which are responsible for triggering the earth basically. So faults mainly occurs within as in fault zone known as what we call the within a zone or along a zone which we call as a fault zone and surface along which the block of rock slip is called as fault plain. We will see those those what is fault plain and all that okay.

And the surface manifestation of such displacements are termed as fault scarps, okay so if we if we look at just a small sketch here then what we see is that suppose this wasn't flat area and there is fault here which will move like this and what we see is something like that okay so this fault has moved to the surface so this was the surface here, this was the surface and this has moved up okay. So this movement along which the land moved okay is termed as fault plain and the expression this is on the surface is termed as fault scarp. We will see some couple of examples of this okay.

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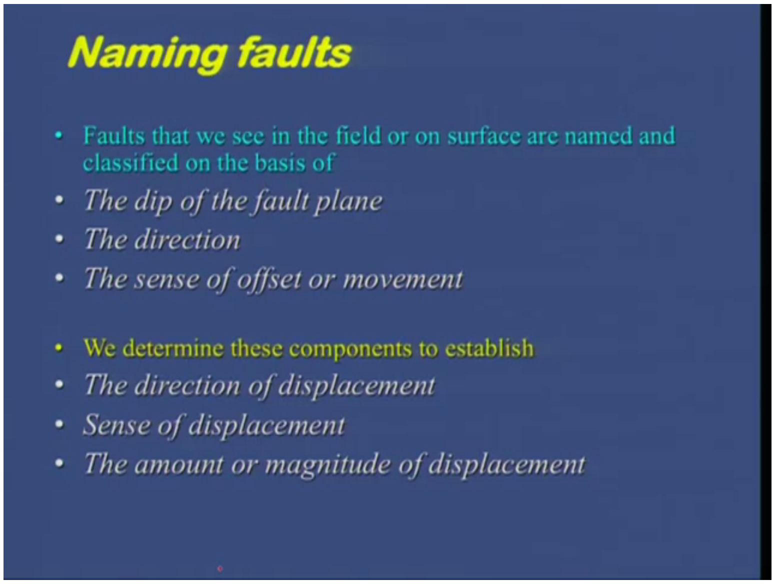

So naming fault, usually what we do is, we take into consideration that how it has slipped okay so on the basis of one, the depth of the fault, what is the angle of the fault plain mainly okay. Then we say that in which direction it moved, whether it moved laterally it moved up or it moved down then sense of offset whether it is a right lateral or left lateral. Then from this we can establish the direction of displacement okay because this information is extremely important for the civil engineers or for any person who are involved in town planning. so and in (this) of displacement then we can talk about the amount of magnitude of displacement so how much it moved okay.

Whether it moved for centimeters or it moved for couple of meters okay so that is extremely important for you to for us to note it down so if you have this information, from this information you can gather or identify these all parameters okay. So with this let us move ahead that how we will be able to differentiate between the different type of faults and how we can determine the the sense of the offset or the sense of displacement again.

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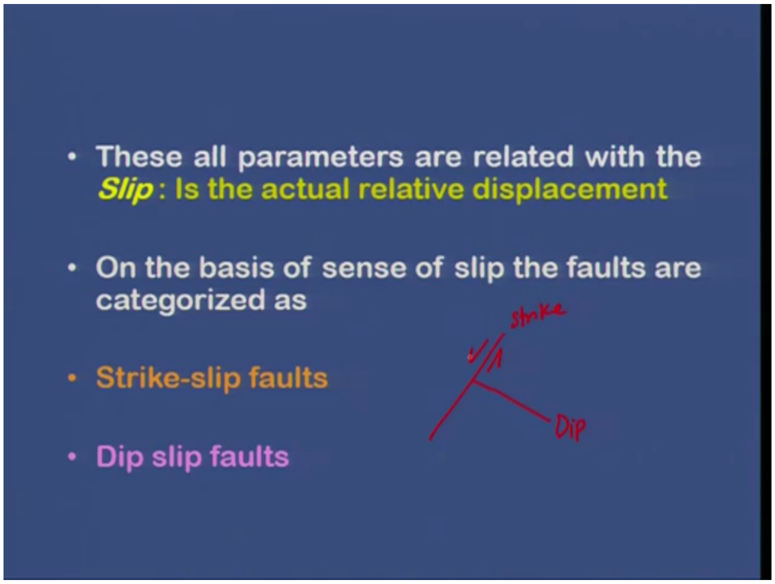

Now mostly what we see is that fault is been like categorized based on the slip and the slip is the actual relative displacement between the 2 blocks okay. So on the basis of the sense of slip, the faults are been categorized as either the normal fault or or the strike slip fault or thrust fault or reverse fault but at the major category if you look at what we look, we identify or categorize is either it is strike slip or it is a dip slip fault so in previous part, what we talked about that one is the the strike we have a strike of the fault and then the perpendicular to this will be your dip okay.

So this is your dip and this is your this is I am talking about the plan views and this is your strike so if the movement has occurred along like this okay sorry so movement has occurred along the the strike then we call that as an strike slip faults along that okay but if they are the movement is occurring along the dip directions then they are dip faults (sar) dip slip faults.

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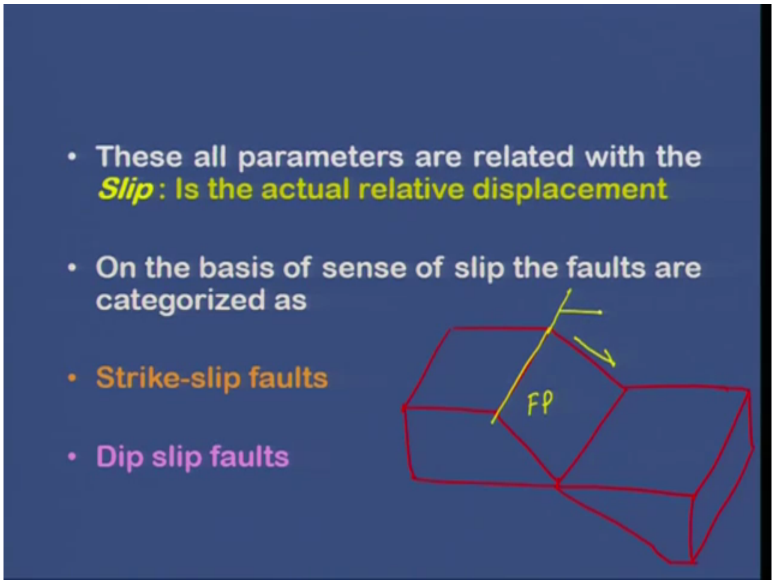

So If we just look at the block here okay, I will just put very quickly okay, suppose we are having, putting a block here so this is the the plane okay having okay so this is what we we have as the this is your fault plain and these are the the blocks which were together once okay so the movement has taken along like this okay so this is the dip plain you are having okay.

So this is the dip direction so if you take this here, this is your strike and this is your dip direction so movement has occurred along the depth okay so this we classify as a dip slip faults okay but the suppose the movement occurs along the the strike then we say that is a strike slip so let us see more signatures of this okay. So in in short broadly we will classify the faults based on the dips, based on the slip that is either the slip is along the strike or either the slip is along the the dip.

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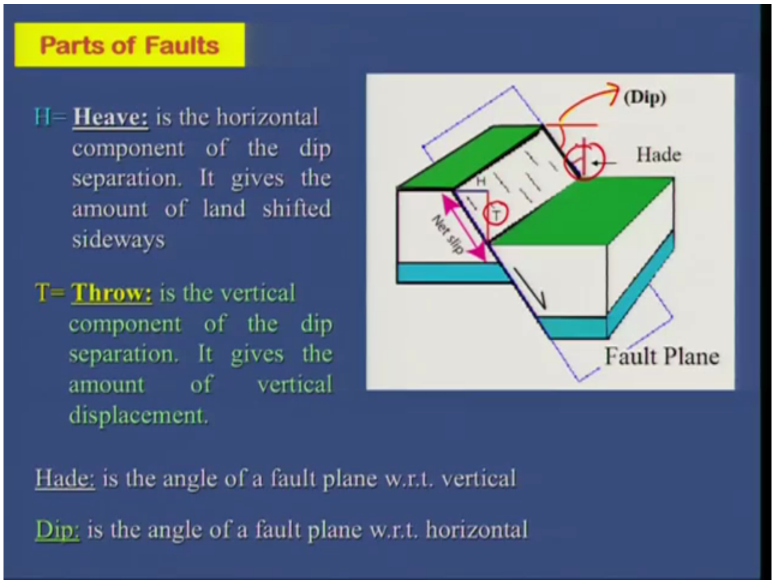

Now parts of the faults mainly we will look at the previous part I was talking about that we have some which are measured with respect to the the horizontal, some are measured with the respect to the vertical okay and the in the previous course, we have talked about that with respect to the horizontal, if we measure, this is what we are having the dip of the dip here okay.

So we have so deep with this that is with respect to your horizontal that is the angle okay and then we have the heave again so heave is the horizontal component of the dip okay. That is horizontal movement or how much we are taking place okay or there is a separation of the land so when when the the 2 this surface is moving here like okay so then we are having horizontal component also so that will be heave okay and angle with respect to the the (lu) the the horizontal, the will be a dip direction so this this angle if you are having the fault plain is here then the angle here will be your dip amount the dip direction will be like that okay.

So this is an horizontal separation which is termed at, it gives the amount of land shifted sideways okay then we have throw, that has been given by here the T is an vertical component of the dip separation and that gives that the how much amount the the land has moved vertically okay and then we are having head that is an angle of the fault plain with respect to vertical so this is an head here okay. So this is with respect your vertical and then we are having dip with respect to horizontal that is the amount of (ang) the angle okay.

So we are having this is what we, it is a different part so mostly when we come across any fault okay so we try to measure the so these components okay, we have heave, throw, head, dip and then we come across for example, if you are to see some layers here okay like for example, one is here and another one is here okay then we can (tak) say that this is the the net slip okay so this is the net slip what we we can measure.

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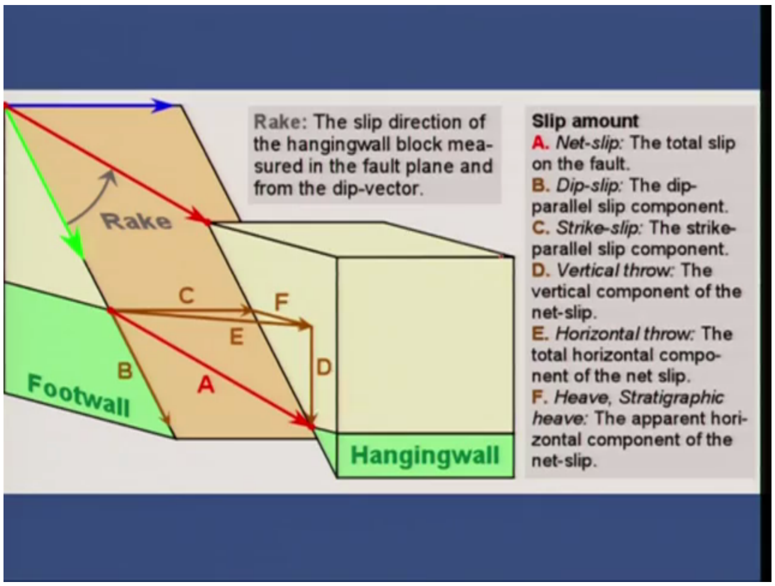

There is another we will explain um diagram which talks about the another component when you are having the dip slip also and you are having strike slip also okay so if you are having combination of then you will come across one more component which is termed as a rake, and the rake is the slip direction of the hanging wall block measured in the fault plain okay and from the dip factor so this is the the rake what we are measuring here okay so other parts are also given here like we are having net slip so net slip is your this one, how much it slipped because this block slipped up laterally along the strike as well as the dip direction okay so this is the net slip what we are having. Then we are having dip slip okay so dip slip is like what we are having this one okay.

So this is the amount of deep slip we are having and this is measured from the tip of this and then tip of this one okay so this is the dip slip amount which we have. Then we are having the strike slip okay. Strike slip is this one okay so along the strike the strike how much it moved. That is C then we are having D vertical throw as we were talking about so this is the vertical throw we are having okay. Then we are having E, the horizontal throw, how much is the horizontal throw here so this is the horizontal throw we are having here. Then heave again, that is again horizontal one okay so we are having the heave is this one. This is F okay so we are having this the heave.

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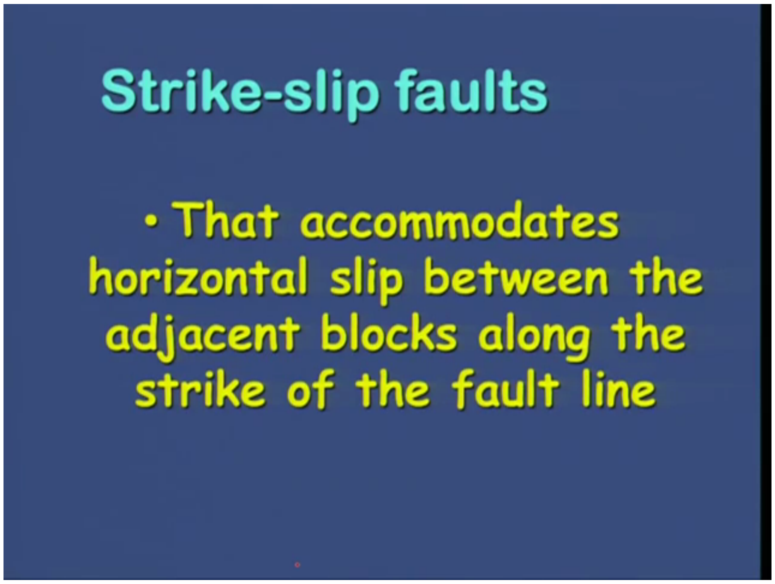

So the strike slip faults, if we if we look at and what particularly we are looking at is the the those faults that accommodates horizontal slip between the adjacent block along the strike of the fault line.

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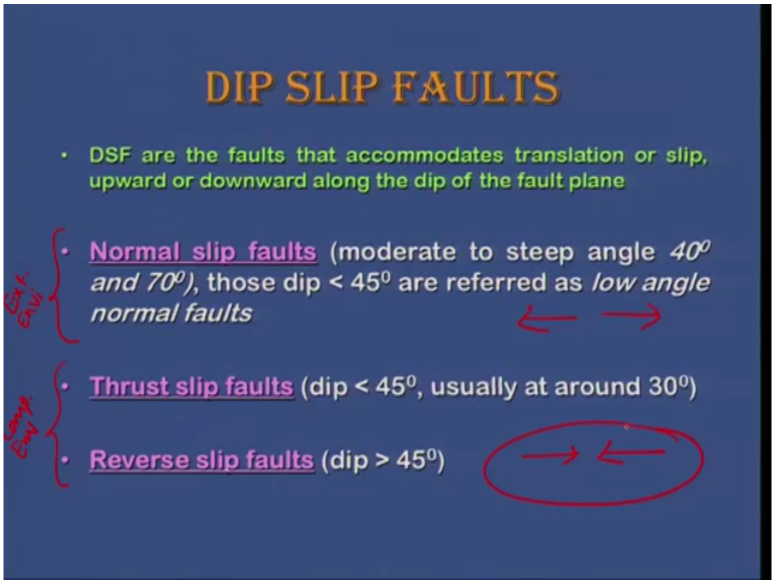

And the dip slip faults further we classify as whether it has the the block has moved upward or the block has moved downwards, based on that we classify that is a normal fault or we say they are the thrust faults or the reverse faults okay now depending on the angle of the the fault plain. We classify that either the normal the normal slip fault was steep angle fault it is an low angle normal fault whereas now so this fault will usually seen in the in the extensional tectonic environment okay whereas these 2 are mostly seen when we are having compressional tectonic environment.

So we are having compressional tectonic environment if we are having extensional tectonic environment where we will see the normal faulting okay so again on the basis of the regional understanding of the structural or the tectonic framework, one can judge that what type of faulting you will expect in that particular region okay and if you are having an oblique then you will the strike slip one okay so mostly in Himalayas we see that this is the the pattern of deformation and we will come across mostly the thrust faults and we will come across the reverse faults so thrust faults are the are the faults which are having dip less than 45 degree so the fault plain will have a the um the dip of less than 45 degree. If it is greater than 45 degrees then they are termed as reverse faults.

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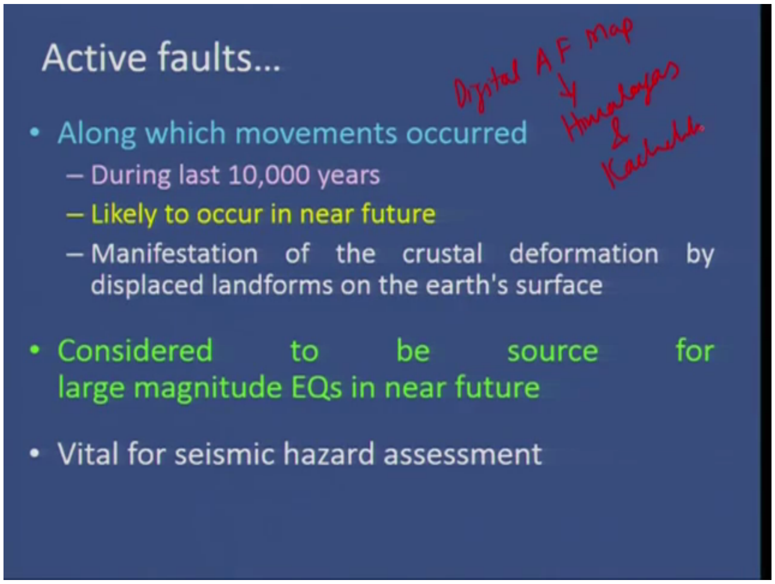

Now, coming to this, active faults okay. What are the active faults. Usually what ub it's been seen that keeping in mind the hazard which are which has been posed to the the human settlements okay, based on that, we have we have identified and we have classified these faults as an active faults. The (fau) These are the faults along which the movement occurred during last 10000 years and likely to occur in near future okay so this is very much important because there is a likelihood of having an earthquake of large magnitude in near future along this fault okay.

And the manifestation of, these are the active faults which have the manifestation of crustal deformation which are seen at on the surface in form of displaced landfalls okay. These are considered to be the source for large magnitude earthquakes in near future. It is vital for the hazard assessment okay and as I told that this active fault information is not available from much of the part from India okay and recently, the ministry of earth science has floated a program of mapping of active fault in Himalayas, in Kachchh region and all that okay.

So that we can come up with a digital active fault map of Himalayas and Kutch region because these are the areas where we have experienced large magnitude earthquakes during recent historic past okay. I will stop here and will continue in the next a lecture. Thank you so much.