Earth Sciences for Civil Engineering Part-2
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Introduction to Geological Hazards and Environmental Impact (Part-1)
Module 1
Lecture No 1

Hello everybody and welcome back for this second part. Okay and before I start I would like to wish you all a very happy new year. Now, as we discussed that this course the second part we will be looking at exclusively on the the hazard one and then second is how important is the geological structures in from the civil engineering point of view.

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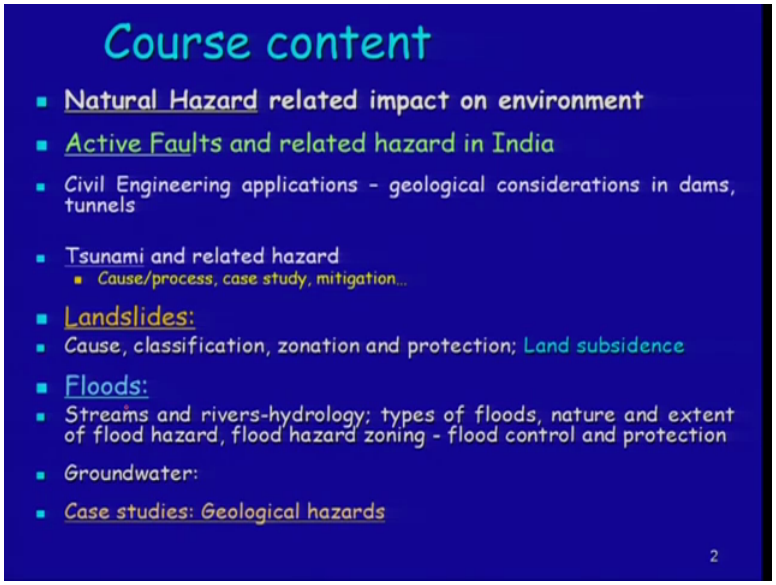

So let us straight away move into the the content of this course where we will be talking the natural hazards and its related impact from the environment. Now here the environment will also include the we will be talk about the human impact, what what is the the impact of natural hazards on the human settlements also. And then we will talk about the geological structures, mainly the active faults and the related hazard in India and we will also include the folds and faults and all that taking into consideration that how they are important in civil engineering applications while putting the major structures on the surface okay and what is the importance of the faults there or the the folds.

And we will have at least one lecture where we will be talking about the the constitution of geological structure while putting the dams and tunnels or selecting any site for construction. Then we will have few lectures on Tsunamis and related hazard, causes, processes and case study. So in case study, we will talking about what happened in 2004 in India because we had a very major event of 2004 along Sumatra Andaman subduction zone.

Then about the land slides, causes, classification, zonation, protection and land subsidence. Then we will talk about floods, again in that we will talk about the streams and river hydrology, type of floods, natures and extent of floods, floods hazard zoning, flood controls and protection and finally the groundwater. Now this we have added with an request we have we got the previous course that there should be some mention about the ground water so I will try my best to talk on the groundwater part also.

Now as we have listed down here, right from the actual hazards and then we are having active faults here so why we will be we will be talking about why the active faults are important and if you look at here that this we are talking about active and the faults we have studied in the last course also okay, so we we will see that how they are important and then all this um topics which are listed here is a part of a the geological hazards okay and it is extremely important for us to to know and understand where exactly these events are occurring.

Unless and until we are not having the complete understanding of the geological processes, it is difficult to minimize the hazard and risk factor okay so this is what we will talking in this course so… and finally we will talk some case studies on the hazard part.

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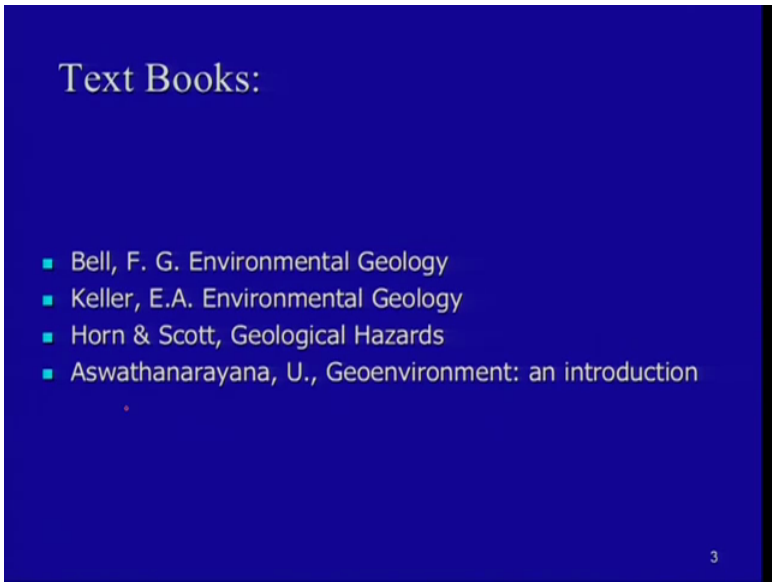

Text books, we have listed few but I would suggest that it is always good that if you follow the slides okay. Nevertheless you can prefer the textbooks also for these topics.

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Now I am coming with the the first part okay. There is the first topic, we will talking about the hazards okay but I would say that these are all natural processes and in previous course, we have talked about that these natural processes are endogenic and exogenic okay. Those processes

related to earth which are taking place subsurface and those are we we term those as endogenic processes and exogenic processes which are taking place on the surface. But all these processes, when the human settlements or we face problems okay then they are hazardous okay.

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So we can say they are all geological processes and if these processes are hazardous to us okay then we term these as an geological hazards okay so why we say that okay, all geological processes are hazardous, it may not be totally correct also okay because if the population is less in many particular areas and those processes are not going to affect then in that sense, they are

not hazardous to us. But in view of the increase in, tremendous increase in the population day by day, more people are prose to such type of hazards so that it one of the reason that why in last couple of decades, geological processes are becoming so hazardous to us.

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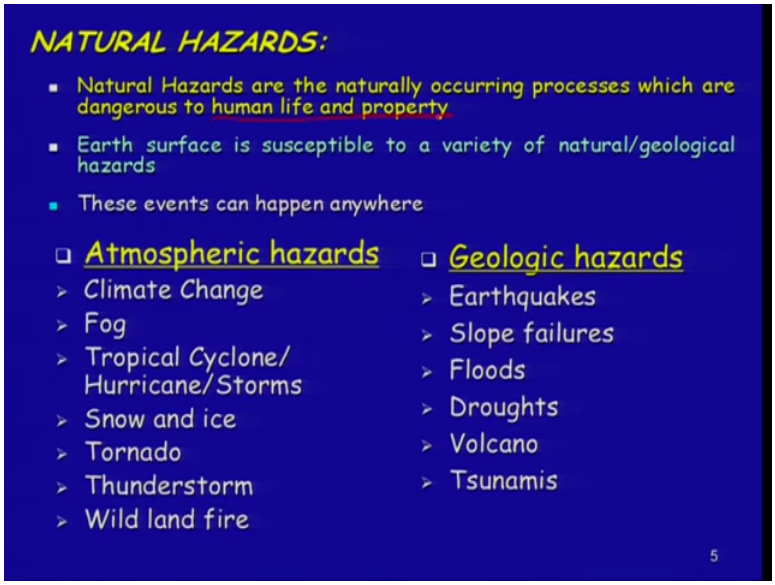

So it is extremely important for us to understand where exactly these processes are occurring and how many people are prose to or exposed to this hazard so natural hazards are naturally occurring processes which are dangerous to human life and property. So we (usu) mostly we are we are bothered because they are affecting our lives and property. Earth processes or earth's surface is susceptible to variety of natural or geological hazards.

Now these events can happen anywhere okay. Now, in terms of the atmospheric hazard broadly one can classify that the climate change, fog, tropical cyclones, hurricanes, storms, snow or ice avalanches, tornado, thunderstorms, wild fire etc and geological hazards, we talk about the earthquakes, snow failures, floods, droughts, volcanoes and Tsunamis.

So there are number of things which are hazardous and we have been talking about for example the climate change of course because of the increase in temperature and all that. We are facing lot of problems and we have experienced it in recent past several extreme events okay.

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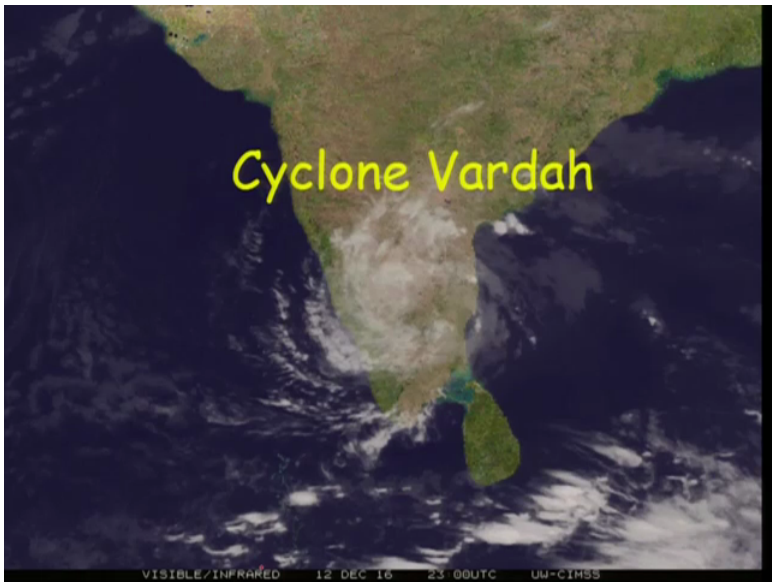

So this was the recent one we had, the Vardah cyclone okay. Now, again as I was talking about that we need to know that which type of event will occur where, that is extremely important for us to understand the process as well as to understand that how we can minimize the the risk part from out of it okay. So cyclones mostly will be forming in ocean and it will be affecting mostly the coastal areas okay so this is one recent example which I wanted to share with you and we all have very fresh memories about it. This was one of the the devastating event with a very high velocity which affected the east coast of Indian mainland.

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So if you look at some of the details of Vardah, how it developed and how it progressed so it started developing on 6th of December over Bay of Bengal close to Andaman Irelands and then it moved (sou) westward. It crossed Tamilnadu coast near Chennai on 12th of December and after the landfall, it moved southwest and weakened. Hardly 18 people were been killed here. Now, this we will talk in very short time that why this was like 18 people were been killed, not more through it was a severe cyclone storm but it did not affect many people okay. Of course it the the affect was very dramatic, it uprooted several large trees, experienced high waves like height of the waves were quite high along the coast.

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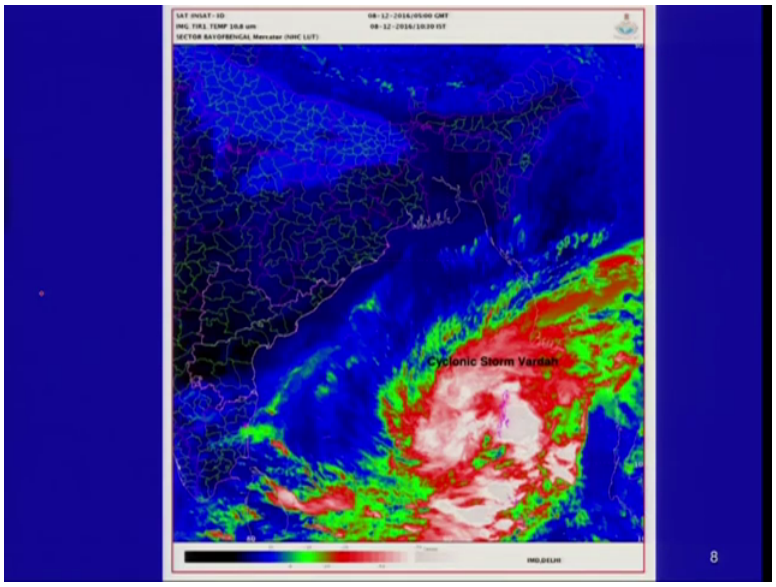

Now, the only reason why we we see only like like the 18 people were been killed, the main reason was that it this this storm was monitored very precisely so if you if you understand, you monitor any hazardous event, you can minimize the life loss and property. Of course it was difficult to save the property but yes, of we were able to save out of from from the Indian eastern coast of India mainland okay.

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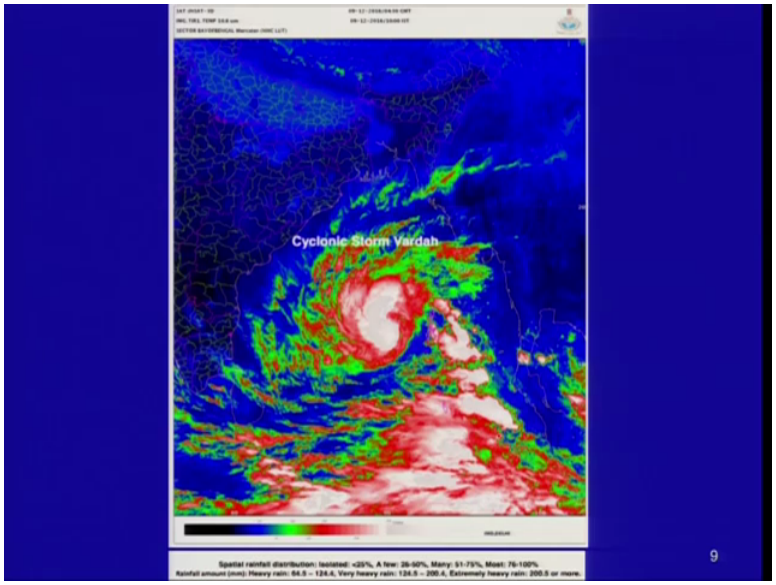

So it started developing on Andaman area and then slowly it moved towards the west okay so these are the all pictures which were been taken at different time.

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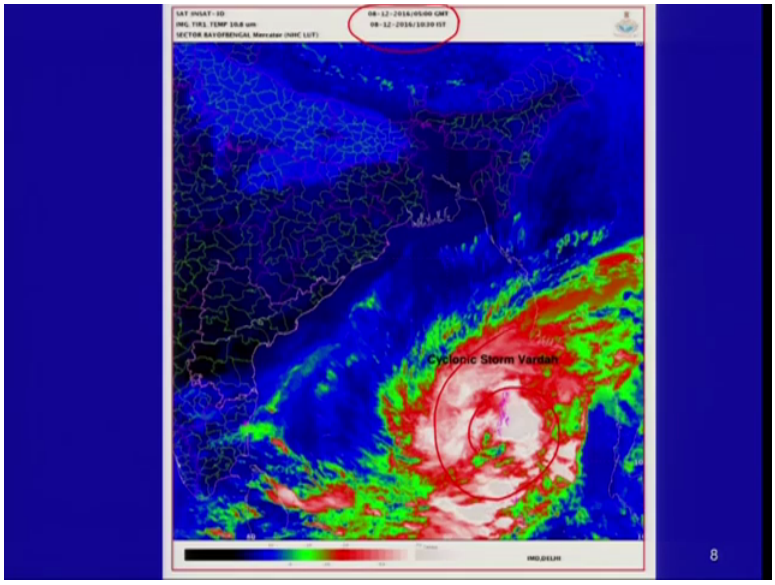

This was then it was been taken on 8th of December where it shows that the cyclone started forming okay so it has an this is the direction of the cloud's movement here. It's moving like this. Okay.

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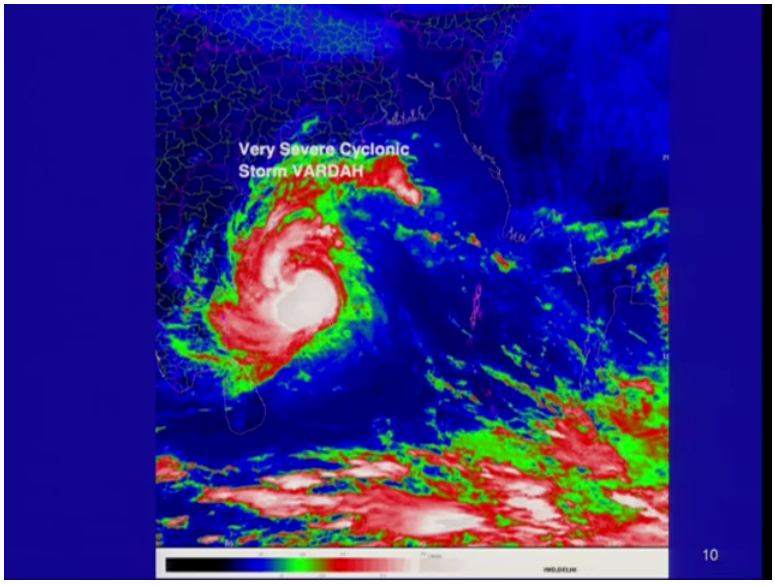

Then it moved further west so this photograph was taken after on 9th or so.

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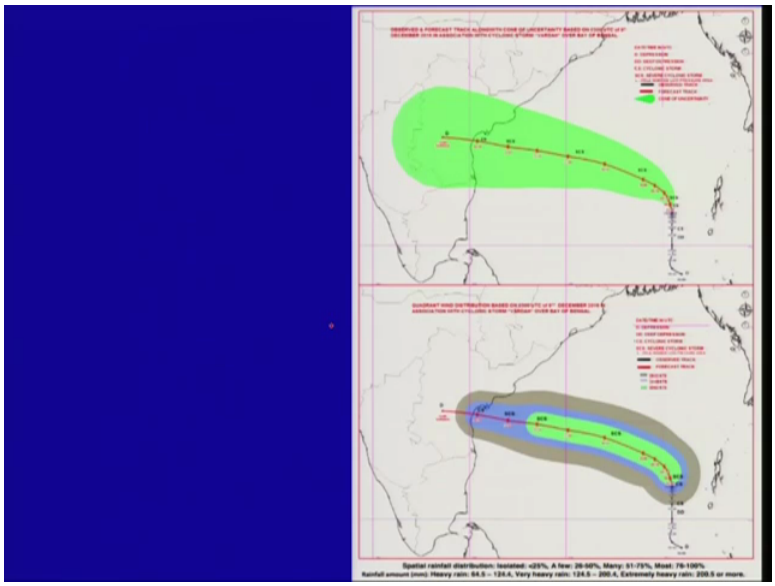

And this is the track which has been shown so they knew the velocity, they knew the the time, at what time it will reach or hit the the coast hence they issued the warning. So this is very much important in any type of hazard that you need to issue the warning okay but in case of ub only few hazards, you will be able to issue the warning okay otherwise it is difficult. For example, this cyclonic part okay, if you take, they had an opportunity to views this based on the ub from the satellite data and they issued the warning but there are few events which are not occurring so frequently hence it will be difficult to predict or issue the warning okay. We will talk about the about the earthquakes and other because it is difficult to predict until now okay.

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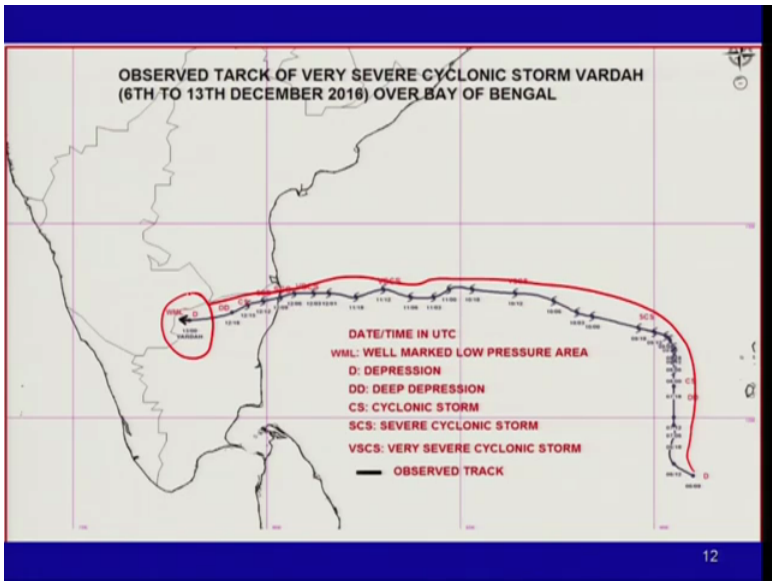

So this was the track which shows how it moved, okay. It originated from here and it moved across this. That's where in on this was the final landfall on 13th okay.

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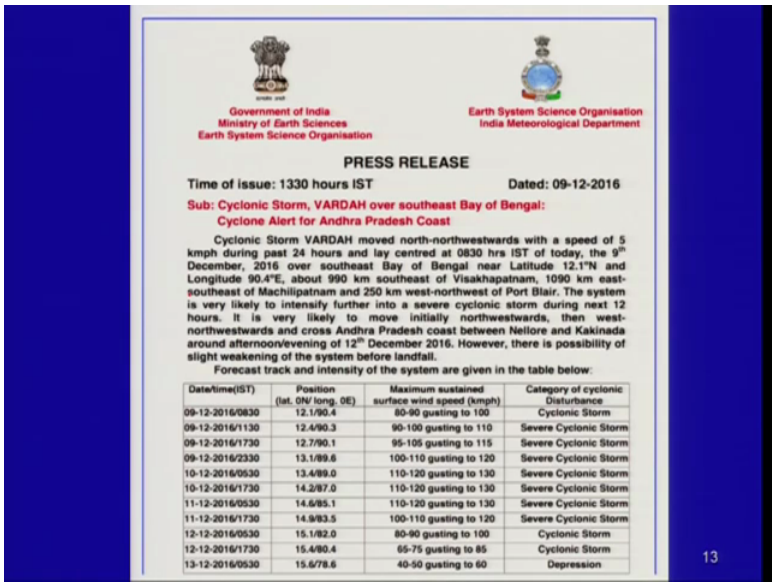

Now, this is what the warnings they have, the way the warnings are issued but this is the press release which was been given by ministry of earth science and Indian Meteorological Department, earth system science organization and all that okay. And they they clearly

mentioned about the the wind speed here okay so if you look at the wind speed on, they say on 13th okay from 12th onwards, the wind speed was quite high okay. It is it is around 100 kilometer per hour and on 13th, it will be around 130 kilometer per hour okay and they have already (iss) ub based on this, they have already categorized this cyclone as a severe cyclonic storm.

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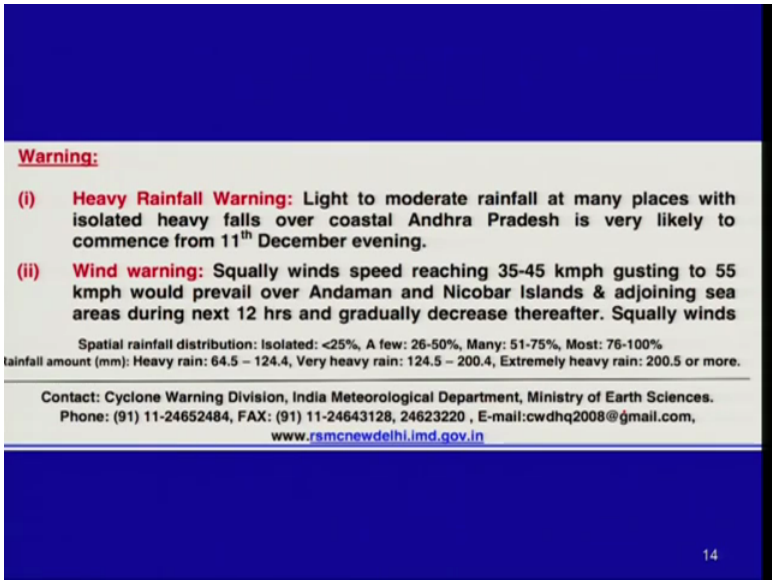

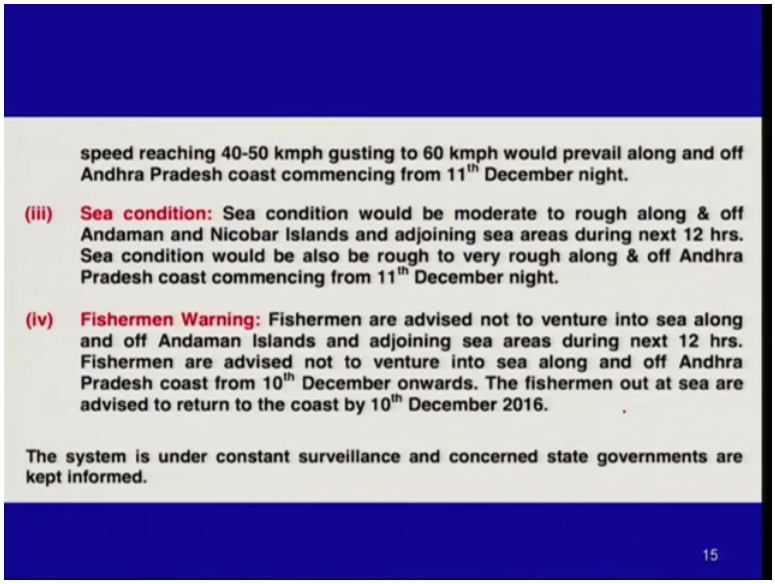

Along with this, they also issued the warnings for the areas along the coastal zones, like for Andaman, they suggested very heavy rainfall in that region on 11th and also they suggested that

what will be the wind speed during that period so the most affected people along the coast will be one is the fisherman's and the people who are staying along the coastal zones okay so fisherman's were also been issued the warning that they should not venture in sea along and off Andaman Irelands and its adjoining areas okay because it is going to be a severe affects of the storm okay.

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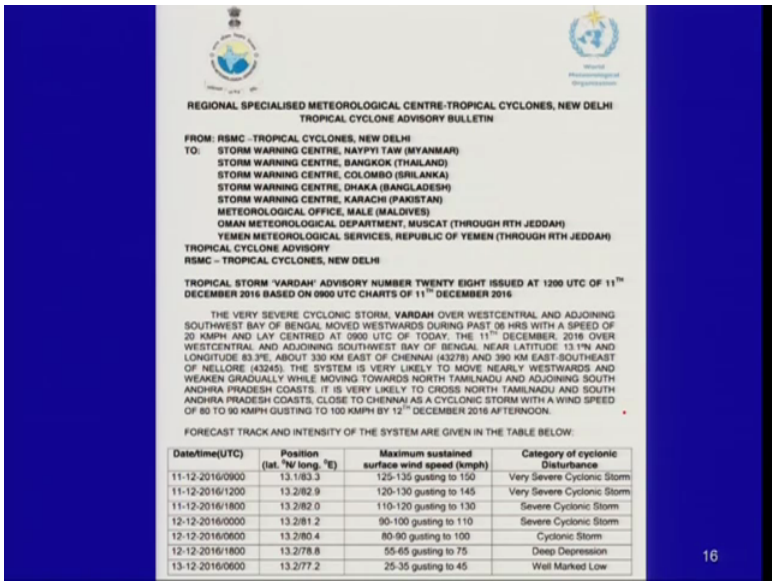
REGIONAL SPECIALISED METEOROLOGICAL CENTRE-TROPICAL CYCLONES, NEW DELHI
TROPICAL CYCLONE ADVISORY BULLETIN

FROM: RSMC –TROPICAL CYCLONES, NEW DELHI
TO: STORM WARNING CENTRE, NAYPYI TAW (MYANMAR)
STORM WARNING CENTRE, BANGKOK (THAILAND)
STORM WARNING CENTRE, COLOMBO (SRILANKA)
STORM WARNING CENTRE, DHAKA (BANGLADESH)
STORM WARNING CENTRE, KARACHI (PAKISTAN)
METEOROLOGICAL OFFICE, MALE (MALDIVES)
OMAN METEOROLOGICAL DEPARTMENT, MUSCAT (THROUGH RTH JEDDAH)
YEMEN METEOROLOGICAL SERVICES, REPUBLIC OF YEMEN (THROUGH RTH JEDDAH)
TROPICAL CYCLONE ADVISORY
RSMC – TROPICAL CYCLONES, NEW DELHI

TROPICAL STORM 'VARDAH' ADVISORY NUMBER TWENTY EIGHT ISSUED AT 1200 UTC OF 11TH DECEMBER 2016 BASED ON 0900 UTC CHARTS OF 11TH DECEMBER 2016

THE VERY SEVERE CYCLONIC STORM, **VARDAH** OVER WESTCENTRAL AND ADJOINING SOUTHWEST BAY OF BENGAL MOVED WESTWARDS DURING PAST 06 HRS WITH A SPEED OF 20 KMPH AND LAY CENTRED AT 0900 UTC OF TODAY, THE 11TH DECEMBER, 2016 OVER WESTCENTRAL AND ADJOINING SOUTHWEST BAY OF BENGAL NEAR LATITUDE 13.1°N AND LONGITUDE 83.3°E, ABOUT 330 KM EAST OF CHENNAI (43278) AND 390 KM EAST-SOUTHEAST OF NELLORE (43245). THE SYSTEM IS VERY LIKELY TO MOVE NEARLY WESTWARDS AND WEAKEN GRADUALLY WHILE MOVING TOWARDS NORTH TAMILNADU AND ADJOINING SOUTH ANDHRA PRADESH COASTS. IT IS VERY LIKELY TO CROSS NORTH TAMILNADU AND SOUTH ANDHRA PRADESH COASTS, CLOSE TO CHENNAI AS A CYCLONIC STORM WITH A WIND SPEED OF 80 TO 90 KMPH GUSTING TO 100 KMPH BY 12TH DECEMBER 2016 AFTERNOON.

FORECAST TRACK AND INTENSITY OF THE SYSTEM ARE GIVEN IN THE TABLE BELOW:

Date/time(UTC)	Position (lat. °N/ long. °E)	Maximum sustained surface wind speed (kmph)	Category of cyclonic Disturbance
11-12-2016/0900	13.1/83.3	125-135 gusting to 150	Very Severe Cyclonic Storm
11-12-2016/1200	13.2/82.9	120-130 gusting to 145	Very Severe Cyclonic Storm
11-12-2016/1800	13.2/82.0	110-120 gusting to 130	Severe Cyclonic Storm
12-12-2016/0000	13.2/81.2	90-100 gusting to 110	Severe Cyclonic Storm
12-12-2016/0600	13.2/80.4	80-90 gusting to 100	Cyclonic Storm
12-12-2016/1800	13.2/78.8	55-65 gusting to 75	Deep Depression
13-12-2016/0600	13.2/77.2	25-35 gusting to 45	Well Marked Low

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So and this is the final press release which was been given by again the meteorological center which is very much similar which they were talking about that wind speed may go as high as 150 kilometers per hour that is on on 11th and 12th okay and on 13th, it will reduce further okay. So again they have also issued that it is this cyclone is severe to very severe.

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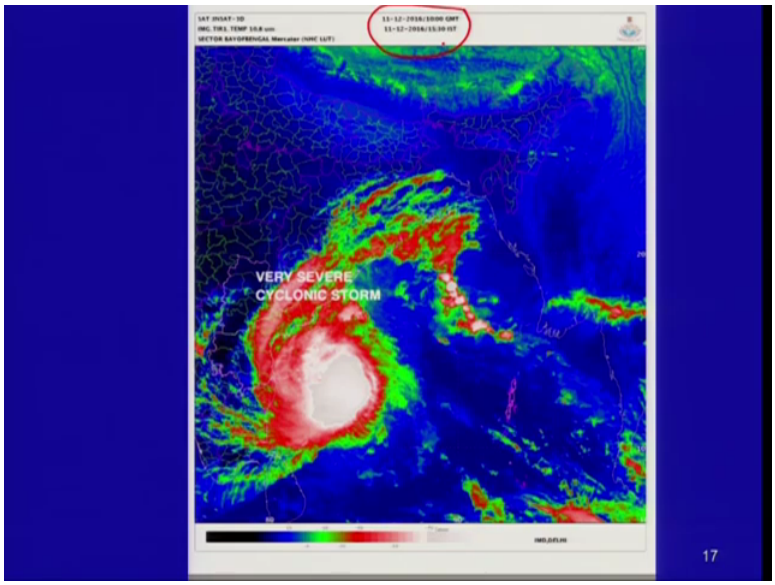

So we had an opportunity to look at the satellite data and this photo satellite image was been taken on 11th which shows at what time it has reached and where umm so you have the time also okay. This is 15:30 okay. 3:30 PM when it approached this area okay.

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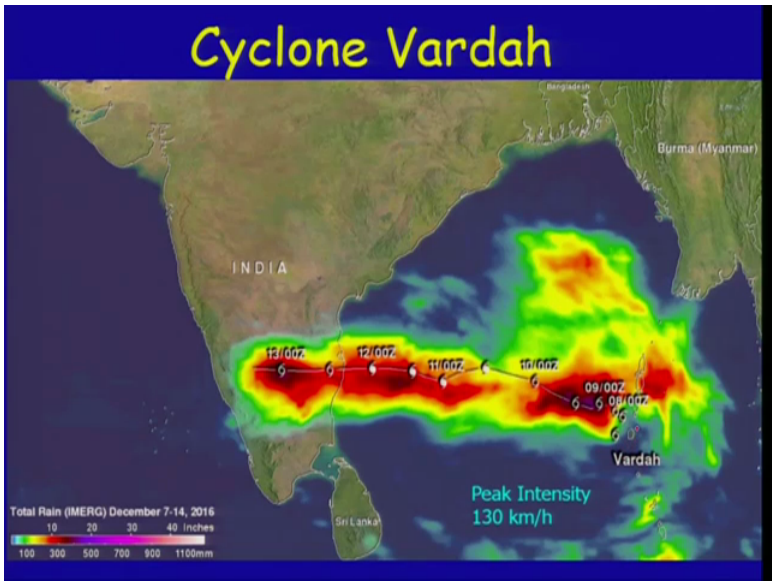

And then finally what we see is the track, it originated from the Andaman, it moved towards west and finally the landfall. So it hit the the Indian coast 12th okay. So we had what we say the proper warning issued for this okay.

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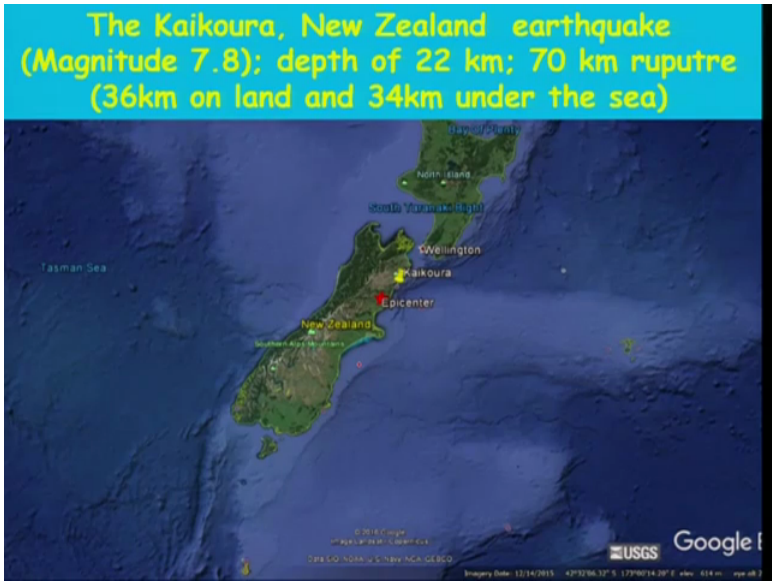

Now, there is another example of the catastrophic events or or we can say the geological hazard, there is an earthquake which happened in New Zealand recently and which is termed as was been called Kaikoura earthquake in New Zealand. The magnitude was 7.8 and it occurred at very shallow, that 22 kilometers and and it ruptured the surface almost covering a distance of 70 kilometers.

36 kilometers was on the land and 34 kilometers under the sea so because of this 34 kilometer which ruptured under the sea, Tsunami warning was been issued okay and if you carefully look at this boundary here, this is the the subduction zone boundary. So let us see some details of this earthquake so I am not going to talk about the rupture here but what is, what you mean by rupture and all that but when we are talking about active faults and all that, you may come across these terminologies and all that but in simple way this is the surface manifestation of the displacement which occurred during an earthquake.

We have couple of videos which shows that the rupture occurred, close to the coast line and on the land okay so we will be showing those videos, 2 videos are there which explains that how the displacement took place during the Kaikoura earthquake of magnitude 7.8.

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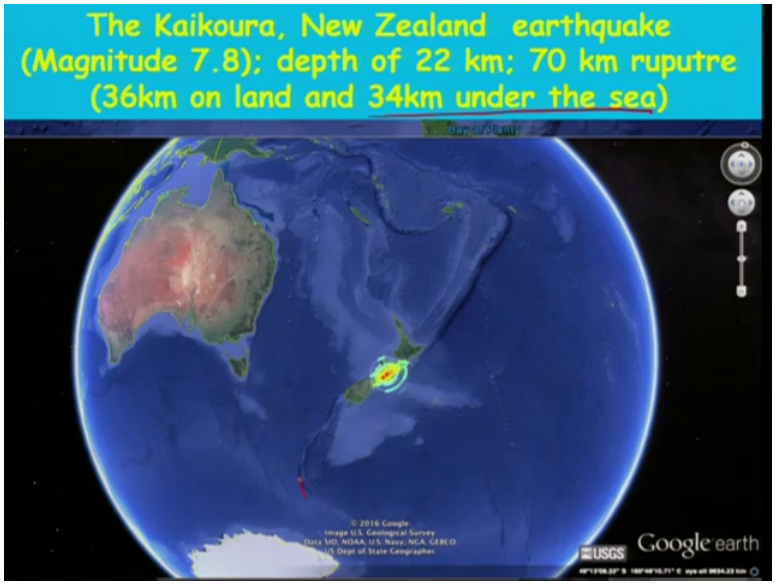

So we have like this is the plate boundary here.

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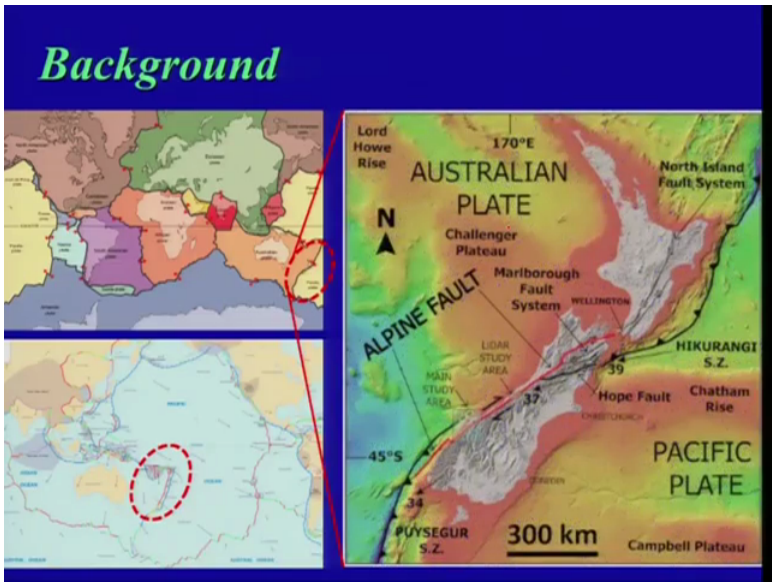

And background if you take, this is the boundary between the pacific plate and we are having the Australian plate okay.

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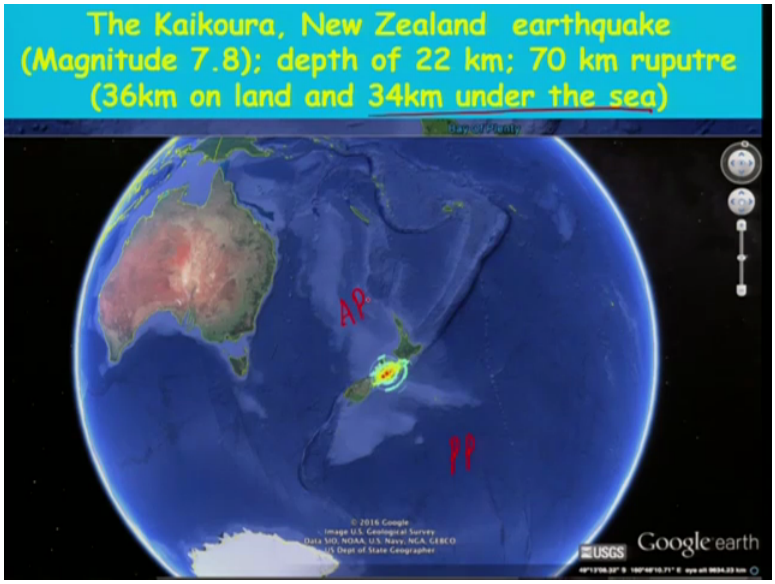

So just I am going back to the slide here so if you take this one, this boundary, this side is your Pacific plate and this is your Australian plate okay so there is a subduction between these 2 plates are taking place.

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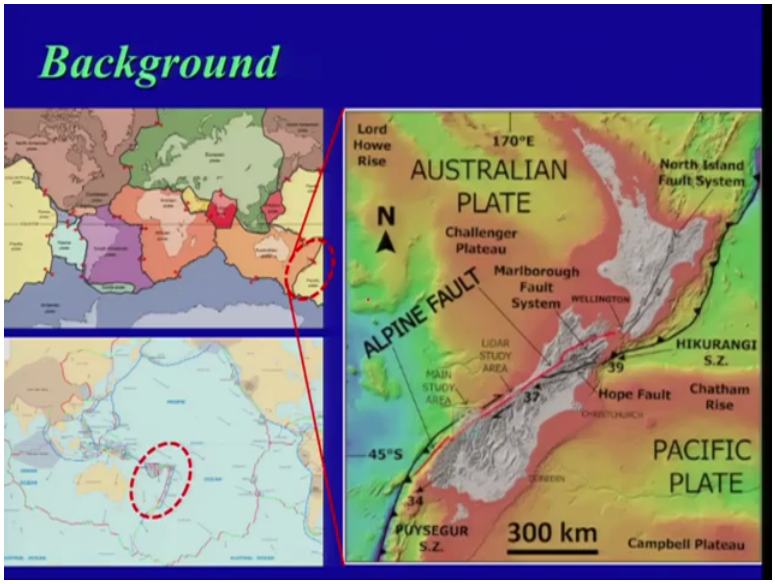

And the movement or the velocity of we can say the conversions rate is too high. We will see this number. It shows around 37 here, 39 here okay so this and then 34 here so these numbers are in millimeter per year. So the pacific plate is subducting below the Australian plate or they are they are subducting as well as sliding passed each other because there is a movement which has been given here so it is a shot of an oblique subduction which is going on here but these numbers which have been shown here 34, 37, 39 are quite high okay because if you take in terms of Himalayas, we have hardly 22 millimeter per year, 21 to 22 millimeter per year across the Himalayas okay.

So this this also indicates that this area, region will experience lot many earthquake but it is again is difficult to predict and at this stage I would say but may in future with the advancement of the science, one will be able to predict the earthquakes and issue warning in proper time okay to save many people. Nevertheless in this region the people not many people were been killed or but the damage was severe.

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As we can see from couple of ground photographs and then land displacement was very prominent in that area okay. The destruction was quite severe as you can see from the some few field ground photographs. Now along with the surface ruptures which are taking place, this could

be (in) probably any possibility of fault scarp which is where we can see the displacement coming right up to the surface so this is your fault scarp here.

So this is nothing but the surface manifestation of the displacement taking place along the fault. Now, apart from this, there is another secondary phenomena which is ub usually been experienced during strong ground shaking is what we called a liquefaction okay so liquefaction will take place far away wherever like even it can take place with a large magnitude earthquake up to like 200 to 350 kilometers away from the epicenter okay so this is not ub restricted to the epicentral area only. And this this occurs because of the the loss of shear strength of the material and the increase in pore water pressure of the water saturated sediments near to the surface.

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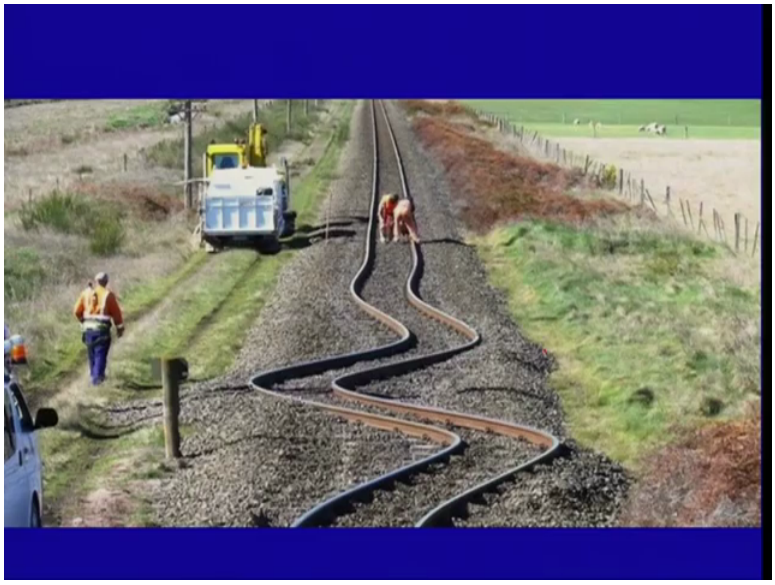

Now, as I told that we have couple of videos which (ca) which we would like to show you okay. Before that so this another ground photograph showing the the rupture and you can clearly see the straight rail tracks getting deformed here okay. So there was a clear cut offset off of the streams, there is again we can categorize the fault ran somewhere here, okay so these tracks have been dragged like this and this is again, this has been dragged like that okay so this is very clearly which shows the the combination of this right lateral movement okay so this becomes like this moves like that okay so it is a right lateral strikes the movement over here.

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Now this is a video which we will play later but I will I would just like to explain that if you carefully see this part here, very sharp boundary or a cliff okay or we can say even the escarpment this is what we call the fault scarps okay so this side is uplifted below before the event, this side was as same as this one okay but this was uplifted and moved laterally so it has an oblique slip along this. Now this is up and this is down here. So this video was been like and the and the fault displacement along the fault is being explained by umm professor Kelvin Berryman, he is one of the very famous paleoseismologist from this area okay so this along the Papatea fault and another video.

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Kelvin Berryman GNS Science


Kelvin Berryman GNS Science


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We are standing here in the Papatea fault, few kilometers south of the Clerance River Bridge on the Kaikoura coast. Looking here at the actually the fault plain, the plane of movement along the fault itself where this side here has moved up by about a meter and a half and we can see the gravels here and gravels on that side but what's really interesting is that we can see lines of

movement here on this fault plane where which are moving down a little bit in this fashion and that means we can see it looks impressive that we are standing here a meter and half high but in fact most of the movement has been along a plane something like this so this side here has moved forward by by many many meters.

These fault scarps formed very very quickly and we know from earthquake physics that probably this fault scarp ruptured across here with speed of about 3 kilometers the second so this has uplifted a very large area of new reef here and the locals here described not the earthquake noise but the noise of water running of the top of this uplifted platform here. They said the the noise was just horrendous and on this side, on the downstream side of the falut, it's actually still even come up about about one and a half meters. On the other side, this is as much as 6 meters of uplift.

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Kekerengu Fault
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The Kekerengu Fault is one of several faults that
ruptured during the Kaikoura Earthquake


Initial surveys show the length of the
onland surface rupture to be approximately 30 kilometres


Initial surveys show a maximum of about
10 metres horizontal and 2 metres vertical displacement

GeoNet

GeoNet is a collaboration between

the Earthquake Commission

and GNS Science

EQC
EARTHQUAKE COMMISSION
Kōmihana Rūwhenua

GNS SCIENCE
TE PŪ AO

Which is along the Kekerengu fault okay and this shows the pattern of rupture along the Kekerengu fault taken by drone so you will you you watch this and then you will understand that how rupture is took place during Kaikoura earthquake.

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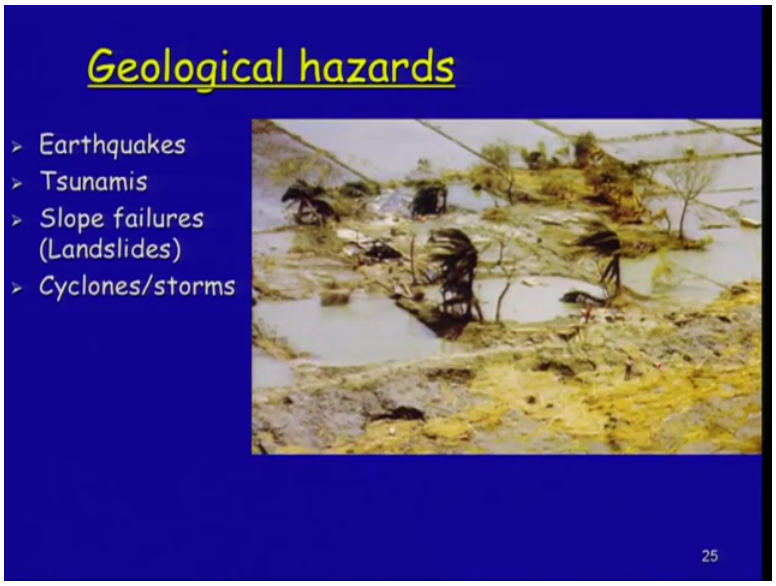
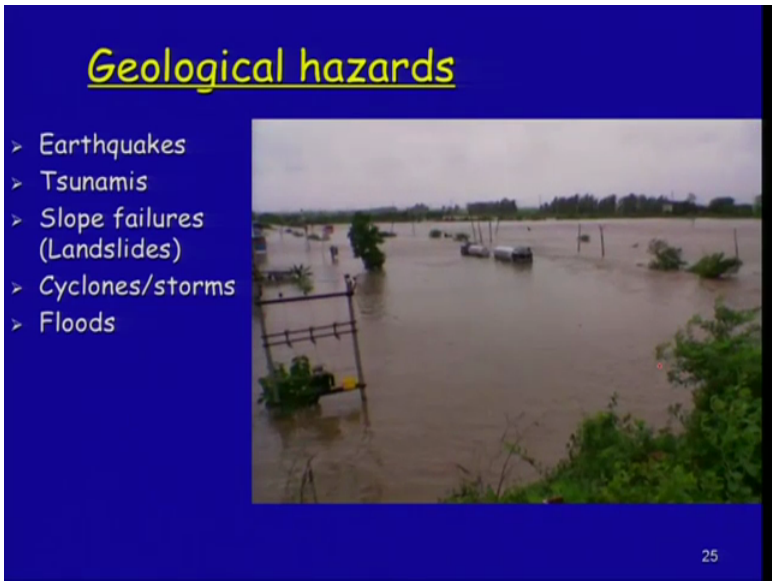
Geological hazards

- Earthquakes
- Tsunamis

Geological hazards

- Earthquakes
- Tsunamis
- Slope failures (Landslides)
- Cyclones/storms





Now coming to the other part, if we consider the (to) in totality the geological hazards so one is your earthquakes and so earthquakes not only result into great seismic shaking and rupture the surface but it damages the buildings and the lifeline structures okay so this is the famous photograph of 1995 Kobe earthquake okay of magnitude around 7.6 or 7.5 and then another one

is the the Tsunami and then we have the snow failures, cyclones and storms okay. And so these are the ub ub few geological hazards which are being listed here which definitely affects the human settlements and the property. Then of course the floods also.

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Now, this is an example from India where usually we have seen that from the Indo Gangetic plain this is from Bihar, every year we face floods in this region okay.

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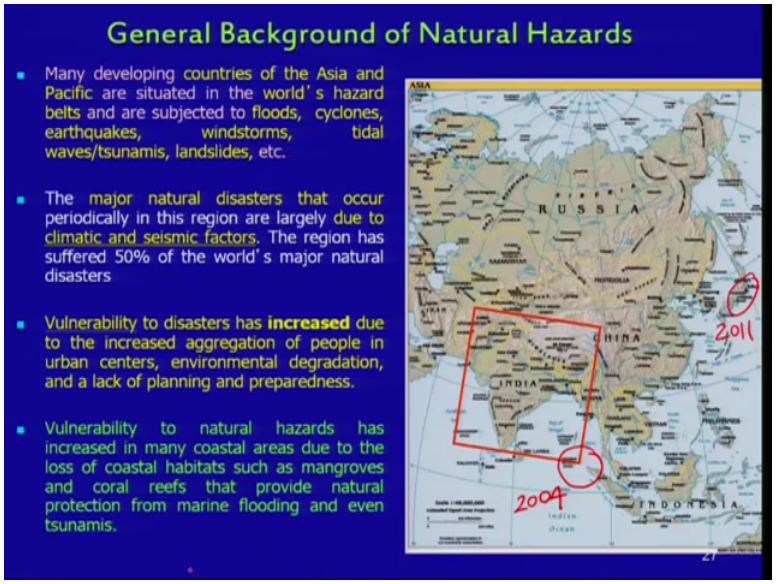

So general background if you take in terms of the natural hazards from the Asia and Pacific region okay so we have usually seen that many developing countries in Asia and Pacific region so Asia we are talking here and the Pacific region is over here so most of the countries from

these 2 areas are situated in worlds hazard belt and are subjected to flood cyclones, earthquakes, wind storms, tidal waves or Tsunamis and landslides okay because we have oceans here so this will result into the formation of the cyclones and the coastal areas will be affected as well as we are having very prominent subduction zones over here okay so that will result into the generation of mega earthquakes as well as we will face the Tsunamis from this region.

So likewise from this area, we had 2004 earthquake and from this area, we had 2011 okay so this is an pacific site, we are having so this whole area got affected by the 2011 Tohoku earthquake and Tsunami and this area was affected. Not only this but other areas also over here but this was been affected by 2004 Sumatra Andaman Tsunami and earthquake. The major natural disaster that occurs periodically in this region are largely due to climate or seismic factors okay.

So if you take here the recent one, from seismic factor, we had 2004 Sumatra Andaman earthquake and from climatic factors if we take, we had cyclone recent that is Vardah and if you go back into in few years back, we had Hudhud, we had Phailin okay so there were cyclonic effects which were experienced along this coast okay. Then further if we talk about the vulnerability, why these areas are are vulnerable and vulnerability to disaster has increased in couple of decades okay

And this is basically because of more and more people are moving towards the urban centers and environmental degradation is there as well as the lack of planning and preparedness so if you don’t do not understand properly the hazard, it will be difficult for you to prepare yourself to minimize the the risk and minimize the hazard part okay.

So vulnerability to natural hazards has increased and the coastal zones also so there is one of the example which has been given that if you keep on disturbing the mangroves and coral reefs okay which usually provides natural protection from the marine flooding and even (Tsu) Tsunami events, you may be affected more as compared to what you will be affected. If they are this mangroves and coral reefs exist and this was been experienced in 2004 where we interviewed many survivors where they had the least affected Tsunami in the locations where they had thick mangroves and coral reefs okay.

So in total if we disturb the environment okay, we may face more problems and if you are disturbing the environment, the the (pro) natural processes are becoming more hazardous to us. I will continue in the next lecture from here. Thank you so much. We will see you next time and during the next lecture.