Introduction to Engineering Seismology
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Lecture – 52
Seismicity of India: Some Past Earthquakes Reported in India

So vanakkam. So we will continue our lecture on Engineering Seismology. So we have been discussing about the past earthquake reported in the country. We also told that the country seismic zonation, okay the four classes what we have seen that 59% of the country actually in the seismic risk zones, okay. So the seismic risk zone means, which is likely to expected a high damage if earthquakes are occurring which we have seen that very high risk zone of 5, okay. The; then the risk zone of 4, okay high risk zone of 4 and then moderate zones of 3.

And about 38 urban settlement are located under these three regions, which we need to be taken into account for the unique city development and the planning. We also look at that. So there was many earthquakes of above 8 magnitude occurred before 1950 that is before independence, okay. So those earthquakes are caused very extensive under severe damage. There is no any recorded earthquake data of those earthquakes, okay, which is very unfortunate.

So because we do not have the seismic instrumentation as we have been struggled during those periods to survive ourselves itself. So there is no seismic instrument, but at least we have the history of those earthquake and damage reports by; collected by the several people and then Paleoseismology study. Paleoseismology study means, so people, they go and dig a pit in that region and they excavate and they see the cross-section of the soil and comment about how the liquefaction is taking place?

How the rupture has happened? If there is some evidence in the epicenter region. So those kind of studies are even people are doing now, okay. So there are many studies they do. So they comment about the past earthquake magnitude and then the size of rupture and the extensive damage apart from the available literature. So, those kind of study Paleoseismology study also taken up.

So then we have seen that after 1950 there are many considerable earthquakes particularly after 1985, okay. So after 1985, there are many considerable the earthquakes are occurred, okay. So but these earthquakes except one or two most of them are occurred not on the plate boundary, okay these are all occurred in the intraplate region as well as in the area which are close to the plate boundary like Delhi region, okay. So those kind of occurs are occurred.

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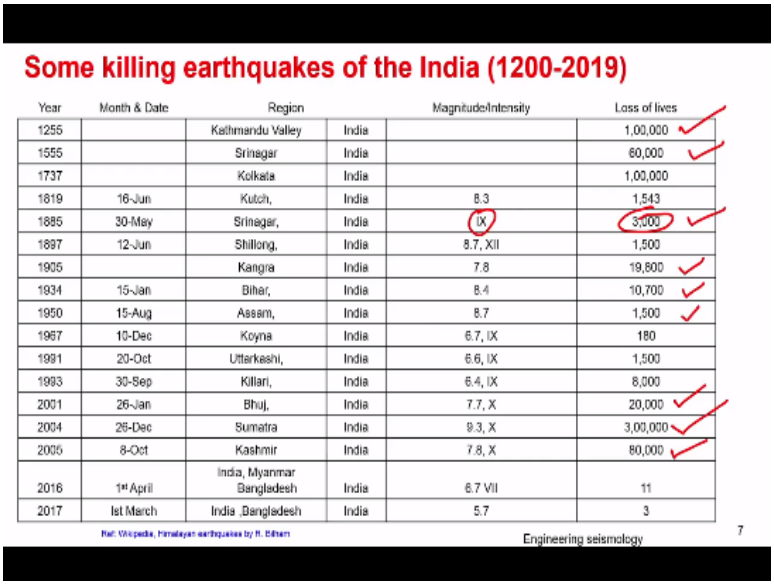

So let us see what are the major killing earthquake in India from 1200 to 2019, okay. So this report I have updated recently, so that it will keep; so; this you will not get straightaway from any book, but it is compiled from the Wikipedia and then from the Bilam website and all those things. So as I told you that the earthquake history is a well-known for India. So there was record says that there was a earthquake in 1255, okay.

So those period which is likely to be the Kathmandu Valley location where the earthquakes are occurred. So about a lakh people died due to this earthquake you can see. So the lakh people on those days is a very big number, okay. So then the 1555, there was a earthquake in Srinagar, so there the 60,000 people died, okay. So then 1737 so Kolkata there is again a lakh people died, okay. Then in 1819 Kutch region so this was actually even the date was given.

Because there was evidence record written literature other 3 earthquakes there is no such written literature. So where they have told that about 1,543 people have died. So if you look at the when

we talk about the fault type, okay we will talk about the normal fault, reverse fault. So during that time, I also discussed that there was a Allah Bund, okay. So where there is a race of the one side of the land that was actually happened due to this Kutch earthquake, which is in between the Gujarat and the Pakistan border, okay. So that is a region.

So then 1885, okay, so 30th May Srinagar there was intensity was reported not the earthquake. It was written as a basically the intensity of 9, okay where 3,000 people died, okay. Similarly, in 1897 Shillong, okay 1,500 people died. This earthquake even has a well reported documents on this. Then 1905 Kangra earthquake 7.5 say about 20,000 people have died, okay. So then Bihar, okay 1934 Bihar earthquake 8.4 magnitude 10,700 people died, okay.

So, 1950 Assam earthquake 1,500 people died. So 1967 Koyna earthquake so the 6.7 magnitude the intensity of 9 has caused. So you can see the intensity values, okay. The relatively the number of people die, you can see. See here 1.000; sorry 180 people died here 3000 people died. But these magnitude are not known maybe somebody should study there and then find out this magnitude. I hoped somebody might have done also. I am not very sure, okay. So 1967 Koyna earthquake, okay so that is what we are discussing where the 180 people died.

So I also told, okay so this earthquake actually the reservoir-induced the earthquake, okay. So this was because of the storing of water in the dam, okay. The source active near that area is triggered and caused the earthquake, okay. So similarly the Uttarkashi earthquake, so again 6.6, okay the intensity of 9, the number of people died is so much. Then Killari 1993 okay, so that is 30th, September, the Killari there was a magnitude 6.4 about 8,000 people died, okay.

So then the Bhuj so these earthquakes we will discuss a little while. We will concentrate on this three. You can see these earthquakes more or less it is similar, okay. So similar in the sense basically, if you look at; so the magnitude wise 6.7, 6.6 and 6.4. But if you look at damage, okay the number of people died. You can see basically the lowest magnitude of 6.4 where people have died many, okay. So you can see 8,000 people have died, okay.

So the 6.6 1,500, 6.7, 180. So there is a; the reverse, okay. So basically the magnitude are increasing like that, but the death is increasing like this. That is what you can observe. So these because the time of the earthquake, okay. The energy released by the earthquake. For example, 6.7 magnitude, okay this was a reservoir triggered earthquake, okay. So the time of the earthquake and the location of the earthquake.

So where the people living, okay so where it occurring in the urban area or close to the urban area far away from urban area and occurring at earthquake at the resting time, resting time means people like evening like five to six from evening to the morning about 8 to 9. So those periods if anywhere the earthquakes are occurring, you can expect a more human loss than the rest of the time. Why because these are all the period mostly all the kids will come back to home.

Family mother will be there; father will be there most of them people complete their work they will be in the home. So occurring of the earthquake at this time is actually very, very disastrous than the earthquake occurring at morning 10 O'clock or afternoon 2 O'clock, something like that, okay. So those are all the factors which contributes here your number of fatality. Even though the intensity looks similar you can see the intensities.

So you can see the intensities are basically all of them are reported 9, but the number of people die see 180 even you cannot even count as a log scale, okay. So even 180 if you make it as a 10 time it will be 1,800 then if you make another 10 time it should be so 180, 1,800, okay. So then the kind of other measurement is just a different follow pattern. So this kind of event very clearly indicates that, okay so the damage not only the earthquake magnitude depend it also the time when it occurs, okay.

It is a day time, evening time, morning time, night time so all those factors also contribute to that, okay. So then we continue our discussion. So 2004 okay so where the 26th, December in Sumatra earthquake so 9.3 magnitude, okay. So the intensity where 3,00,000 people died in India, okay. So this was very unfortunate I told you that the tsunami warning, okay. So we do not have the tsunami warning system, okay.

So because of that even though the tsunami was actually reached after two hour of the earthquake origin time, we could not get any warning. So because of that many people who are gone walking to the beach and the people living close to the coast all of them are died. So after this earthquake Indian Government taken initiative and installed many tsunami warning stations in the Indian sea, okay so to prevent this kind of future lag.

So 2001, 26th, January Bhuj, okay, India there was 7.7 magnitude, which about 20,000 people died, okay. So this was also working day many school, okay it was around the morning time I think around prayer time or something that. So many school was actually damaged a lot of people died particularly this 26th, January 26, okay that is a; some of the festival day where we see that many school kids are; okay so assembled. There a lot of people have died due to that.

So 2005 Kashmir earthquake which is like also called as a Pakistan Kashmir earthquake, 7.8 magnitude 80,000 people have died, okay. So there are many people died in this earthquake due to improper evacuation of the people because of the disconnectivity of the; between the place-to-place due to the many landslide and cutting of the road, okay the road got damaged landslide occurred.

So there is no connectivity between the different places. So that took a long time to establish. By the time many people died due to hunger. Even people got slight injury people because they did not get a proper medication and support. So there are all died. So that was the one of the bad event where we made us to understand that the road networks are very important for the evacuation and the restoration, okay.

So the next the India, Myanmar, Bangladesh earthquake on 2016, okay so where the 6.7 magnitude 11 people have died. And then 1st, March India, Bangladesh again 5.7 so, 3 died, this was actually a Tripura earthquake. So there was another earthquake on 2015 but there is no casualties like Nepal earthquake, which also affected the some part of India, but not too much casualties reported in India that earthquakes are not this one.

So from here, we can more or less clearly understood that if you want you even steady seismic hazard in India, you should will concern with that what happens in Nepal? What happens to Bangladesh? What happens to Myanmar? What happens in Pakistan? Okay. These are all the countries basically geology of this country, okay the tectonic of this country also will affect us, okay. That is a message you can get from here.

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So if you look at the typical golden day's photo shows the damage of this earthquake. This was 1897 Shillong earthquake. So where it is taken from the encyclopedia global earthquake you can see the photo, okay. So you can see how it was disaster. You can see there is a; I think the kind of a Temple, okay or the monk, the station where it has been completely destroyed, okay. So this is a; again a Kangra earthquake you can see here these are all even here, some of them are very traditional this one. So this is actually 1934 Bihar Nepal earthquake.

So you can see here. So these photos basically might be collected from the some of the British people who had that time kind of camera, kind of things, I do not think any of the Indian might have taken this photo. So then this is a 2005 Kashmir earthquake you can see. So how the buildings are completely destroyed, so okay so this one. So during this time, I was actually studying my Ph.D okay, degree program and a course on this earthquake engineering related course, okay so where you can see the lot of this one.

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So this is 2004 tsunami to show you like how catastrophic the lot of damages, okay has occurred. So you can see basically there how the tsunami debris, okay. So it has been, I mean, dismantled and then all the waste what we thrown to sea has been thrown back to the land area, okay. You can see the devastation occurred, okay so due to this 2004 tsunami.

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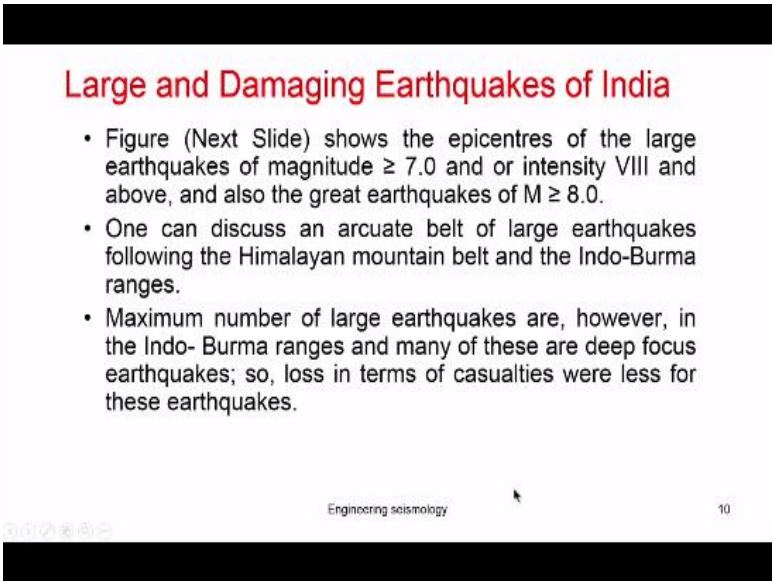

So these are all the earthquakes, okay which very clearly indicate that, okay so the all the seismic hazard, okay are possible at a different parts of India. So let us see some of the earthquake locations, okay what we have seen was actually the damage and here what it reported. So let us see the some of the earthquakes location in the map and try to understand where there earthquakes are more where the earthquakes are less, okay.

So the figure shows the epicenter of large earthquakes magnitude 7 are the intensity of 8 above also greater earthquake of magnitude 8. One can discuss the arcuate belt of large earthquake following in the Himalayan mountains, the belt and the Indo-Burma range. The maximum number of large earthquakes are however, in the Indo-Burma ranges are many of these are deep focus earthquake. So less in term casualties were less than less for this earthquake.

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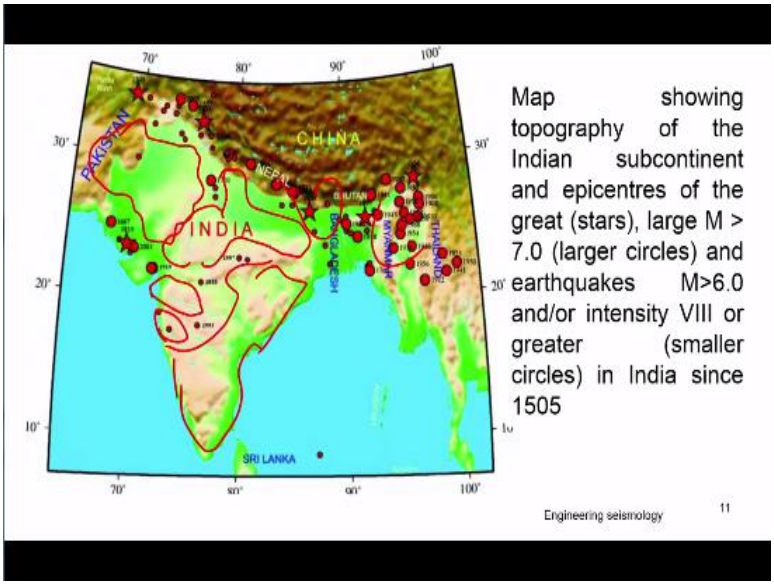

You can see this earthquake actually you can see this was actually magnitude of 8, okay. So then under 7, under 6, okay sorry intensity of 8 and above has been reported. You can see very clearly there is a band of the earthquake, you can see the narrow band of the earthquake in the land boundary, okay. So these are all their shallow focus of the earthquakes. So this is basically Indo-Burma Myanmar region where there is a deep focus earthquake and many events are there.

Map showing the topography of the Indian subcontinent and epicenter of the great earthquake. So the great means, the earthquake magnitude 8 and above. You can see this is the one earthquake grid. So this is another earthquake somewhere here. So then here, okay this is a very old earthquake. So then this one these are other earthquakes. So the larger circle, okay the 7 magnitude and above is shown in the larger circle.

And the earthquake up 6 and above where the intensity of the 8 and above caused as a small circle you can see here all those circles are the small circle. So you can see that there are many area there is no earthquake sub 6 are occurred, okay. So these are all the area basically if you want to see very clearly, okay. So we can map this area as a basically, okay. So then; so these are all less; so more or less if we connect all of them, you can almost get to similar to your seismic zone map, okay where this is higher zone. So these are all the higher zone, okay.

These are all the area very low zones are observed. So which very clearly indicate that this area, okay. So in the last 110 years, okay so there is no bigger earthquakes are occurred or even they say that 1505, okay. So there is no such a big earthquakes are occurred. There may be possibility that this may be like big earthquake means 6 magnitude and above. So this kind of occurrence of earthquake one can expect.

But that will cause many more damages as we are seeing that 6.4 magnitude 8,000 people died, okay. So during the Killari earthquake those are all the evidence one has to be aware to be account when you are doing the hazard analysis, okay that is a message.

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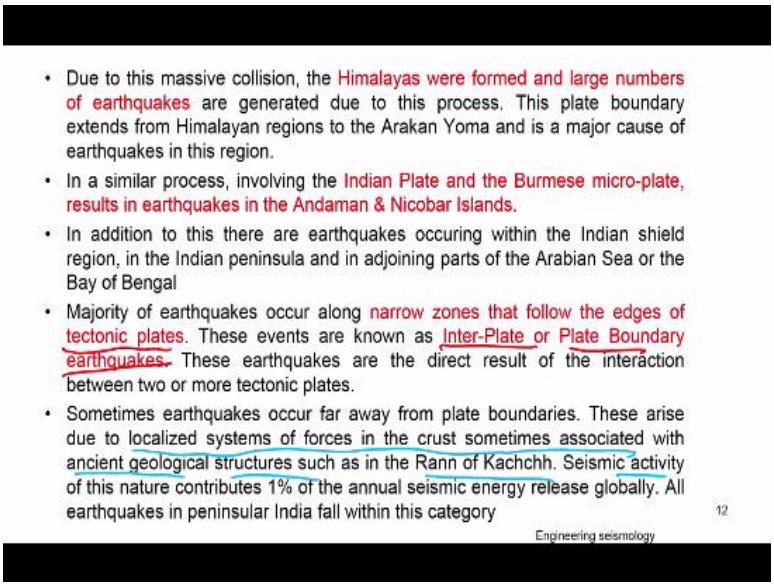

So due to the massive collision of Himalayas were formed and large number of earthquake are generated due to this process, this plate boundary extend from Himalaya region to the Arakan Yoma and is a major cause of the earthquake in; so the Himalayan belt because of the collision

between the say Indian plate and then the Eurasian plate and then the Burmese plate all those things are basically causing several earthquakes in the border, okay.

So the Himalayan Indian plate boundary border, okay. And also this side Indian Burmese plate boundary border. In addition to the earthquake occurring in the Indian shield region, Indian peninsula and adjoining part of the Arabian Sea and Bay of Bengal, okay these earthquakes also significant. So majority of earthquakes occur along the narrow zones that follow edge tectonic plate that is what we are seeing in the; this one.

And these events known to be inter-plate or plate boundary the earthquakes, okay. So basically, the earthquakes are occurring on these places. Okay, so these places you can see that. So you can see that there is earthquakes are following a narrow band, okay. So this narrow band due to the plate boundary action, okay. So sometime earthquakes occurs far away from the plate boundary this arises due to the localized system of forces, okay.

The crust sometime associated with the ancient geological structure such as Rann Kachchh seismic activity of the nature contribute 1% of the annual seismic energy released by the global. So the Rann Kachchh is actually the interplate, but because of that the formation of the plate tectonics, okay. The formation of the plate tectonic and the moment and the tensile force caused due to the moving of plate and rotation of the plate causes a many earthquakes in the Rann Kachchh which is almost 1% of the annual seismic energy released globally. All the earthquakes in peninsular India falls under the intraplate category, okay so where this contributes to the seismicity.

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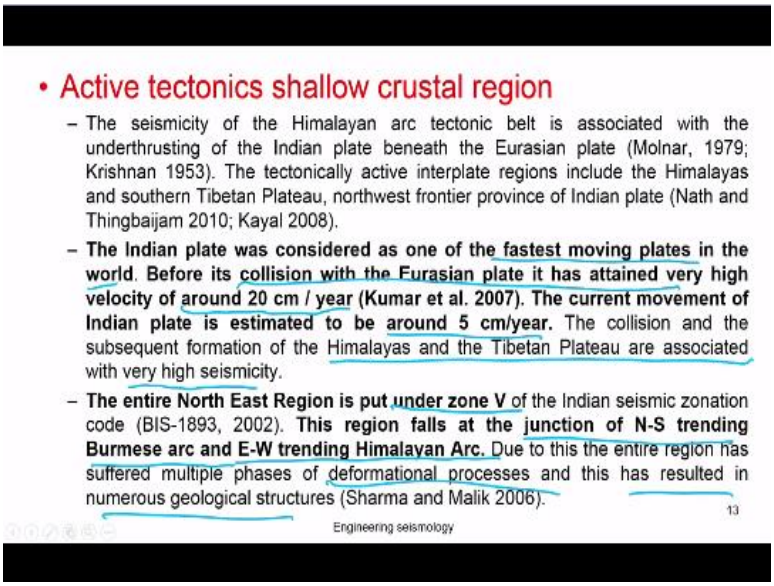

So the entire Indian can be divided into three major seismic zones or the tectonics, okay. One is that active tectonic shallow crust region. So the seismicity of Himalayan arc tectonic belt is associated with the underthrusting of the Indian plate beneath the Eurasian plate. The tectonic active inter-plate regions are include Himalayan and southern Tibet plateau, northwest frontiers province of the Indian plateau. So these are all the regions are called as a active tectonic shallow crust region.

The Indian plate are considered as one of the fastest moving plate in the world, okay. So before it collided with the Eurasian plate, so it was moving very fast collide with the Eurasian plate, okay so earlier it was moving with speed of 20 centimeter per year. So the current moment of the plate we estimated to be a five centimeter. Once it hit the Eurasian plate the speed was reduced considerably, but still it is pushing so, I did not have the speed it is pushing, it is pushing around 5 centimeter per year. So we are losing our Indian land by 5 centimeter per year, okay.

So if the sea level continuously raises, okay this losing of land where many of the sea region, okay the region around the coastal, okay area were losing the too much land, okay. The collision and subsequent formation of the Himalayan Tibetan plate are associated with the high seismic activity. So because of this collision only you have a very high seismicity in this region. The entire northeast region is put under a zone 5.

The Indian seismic zonation code BIS-1893, this region false junction of north south trending Burmese arc and east west trending the Himalayan arc. So these two arc basically responsible for that due to this entire region has been suffered a multiple phase of deformation process and this has resulted in the number of geological structures, okay. So these are the some other geological study done by the Sharma and Malik, they have published this information.

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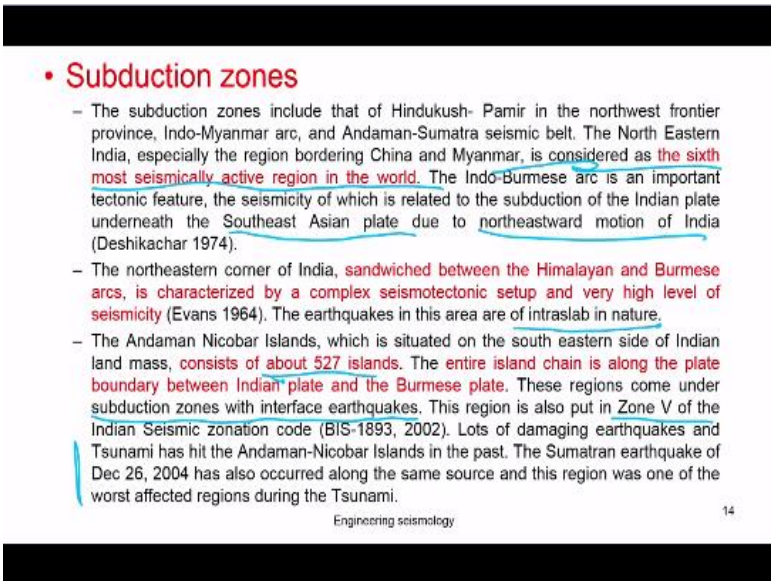

The another is a subduction zone, subduction zones include Hindukush- Pamir in the northwest frontier province, Indo-Myanmar, Andaman-Sumatra seismic belt comes under this category. The North Eastern India, especially the region China Myanmar considered the sixth most seismically active region in the world. So the Northeast is the sixth most active region in the world.

So the Indo-Burmese arc is important tectonic feature seismically which relate subduction of Indian plate underneath the Southeast Asian plate due to the northwest motion of the Indian plate, okay. So the northeastern corner of India sandwiched between the Himalayan Burmese arc and is categorized by a complex seismotectonic setup and very high level of seismicity. The earthquakes in this area are interslab in nature.

So these informations are needed because when you want to take a particular model to estimate the hazard you should know that what type of model is suitable for a particular region, okay. So

far; that this kind of classification and understanding of tectonics are very important. See Andaman-Nicobar Island which is situated the south eastern side of Indian land mass consists about 527 Islands.

The entire island chain is along the plate boundaries India plate and Burmese plate. These regions come under subduction zone, okay so this is basically a subduction zone, which interface earthquakes. The region also put in the zone five the Indian Seismic Zone code last damaging earthquake of tsunami in Andaman-Nicobar Island in the past. The Sumatran earthquake December 26th, 2004 occurred on this kind of region. So these places and whenever seismicity happens are the subduction zone, okay.

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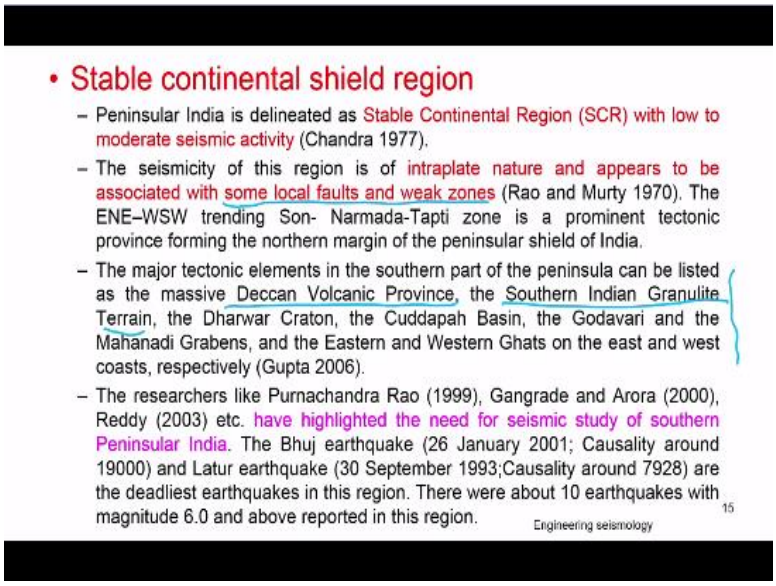

So the another zone is actually the stable continent shield region. The Peninsular India delineated as stable continent, okay with low-to-moderate seismic activity, okay during the 1997 Chandra carried out, okay the detailed study and he classified so this region. The seismicity of this region interplate in nature appears to be associated with the some local fault and weak zones. So the Rao and Murty carried out study.

And they commented about that most of the earthquake occurring in the southern part or Peninsular India, okay or due to the some local fact and a weak zone due to the mass scale activity in the plates. So the east north east trending and west south trending Son-Narmada-Tapti

zone the prominent tectonic province the northern margin of the peninsular shield. The major tectonic elements of southern part of peninsula can be listed as a massive Deccan Volcanic Provinces, the Southern Indian Granulite Terrain, okay.

These are all the some of the geological and tectonic, okay the names in the Peninsular India are different part. Dharwar Craton and Cuddapah Basin, Godavari and Mahanadi Grabens and the Eastern and Western Ghats, okay. So then the east and west coast respectively. So these are the some of the tectonic major tectonic elements in the southern part of India, okay. So the researcher, okay like a Purnachandra Rao, Gangadhar Rao, Arora and Reddy have highlighted that need for the seismic study of southern Peninsular India because many of the earthquake sources are identified after the earthquake.

For example, the Killari earthquake, Koyna earthquake, Jabalpur earthquake after the earthquake only study has been carried out and found that, that is faults are active, okay. So if they are carrying out a detailed seismicity study in the region will help to identify any such kind of sources exist as we have the poor seismic recording and we have seen that many in parts of the India okay.

So where there is no seismic record, okay. But because of the lack of seismic instrumentation and the record we classified those regions as a low seismicity zone, a low risk zone in the (()) (27:56). The Bhuj earthquake 26th, January 2001 casusality around 19,000 people, Latur earthquake again 1993 somewhere around 8,000 people, okay are the some of the deadliest earthquake in the stable consentient region. There are about 10 earthquakes with the magnitude of 6 and above are reported in the Peninsular India, okay. So these are all the major three active tectonic region.

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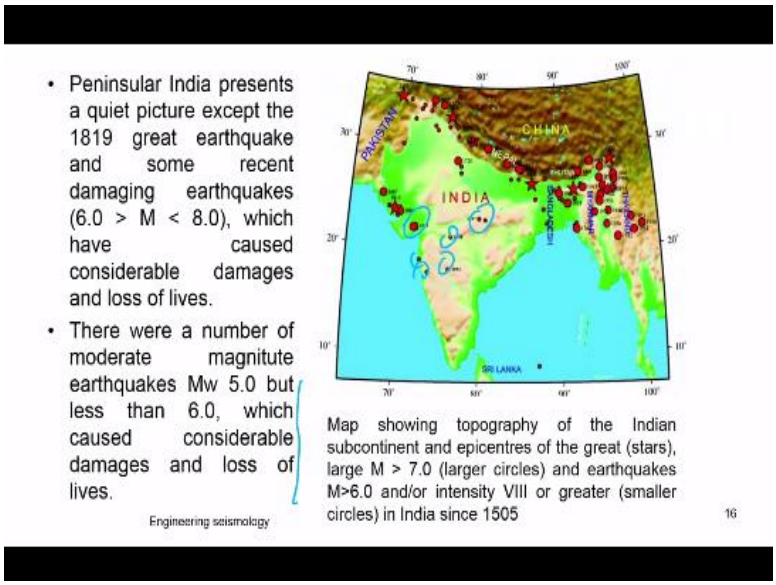

So the Peninsular India presents, okay so, quite picture except to 1891 greater earthquake some recent damaging earthquakes. So the same figure we are talking about the earthquakes. So this the nature because we are talking about the peninsular earthquake. So there are a number of moderate magnitude of 5 but less than 6 which caused considerable damage and loss of lives in the Peninsular India which was not marked in this map actually, but if you can study the seismicity, you can get all those information.

So this gives the overall view of the how the earthquake data a damaging earthquake or a killing earthquake reported in the India, okay. That is what we could able to understand. So now we have to at least glance through if not all the earthquake the major earthquake from different parts of India to understand how these damages are caused, because if you understand this only you could be able to predict damage or hazard due to the future earthquake.

So for that purpose, we need to individually understand each and every earthquake based on the recorded data available are the information available from the past, okay in the form of literature or report whatever that will help you to give you a more insight view of this earthquakes. So with this, we close this class. Thank you very much for watching this video. So we will meet you again and discuss continue our seismicity of India, okay for a different big earthquakes caused. Thank you very much.