Introduction to Engineering Seismology
Prof. P. Anbazhagan
Department of Civil Engineering
Indian Institute of Science – Bangalore

Lecture – 42
Seismic Zonation and Microzonation Continued

So welcome so we will continue our lecture on engineering seismology. So, we have been discussing about the zonation okay. So, what is mean by zonation? So why is zonations are important? Why do we need a zonation? So, we are seeing that zonation as can be done at the continental level and the country level, regional level and site level. So, we are also seen that where you can adopt a site level okay site level can be adapted for the important structures and important facilities okay so like dam, nuclear power plant okay.

So, the multi-story apartments where the thousand families are kept together. So those are all the places site level studies maybe record okay. So the zonation defines okay basically so the area which has similar seismic activity okay that is a (()) (01:11); so we will continue our zonation concept we also seen a 3 type of zonation as our macro level micro level and the nano level okay but this concept has been developed in 1999 so where is a considerable lack of scientific advancement okay so but it is closely able to 20 years back now we are advanced well.

So, where people also looking for the very minute level of information for the design and other things we also try to understand what is the difference between the seismic zone and the seismic risk we should not misunderstood risk as a zone, zone as a risk we also seen that zonation map for the general requirement zonation map for engineering requirement zonation map okay so its component we have discussed and also we have seen seismicity map okay the seismic zone map and the seismicity maps are completely different. So, if you recall what we defined as a seismic zonation.

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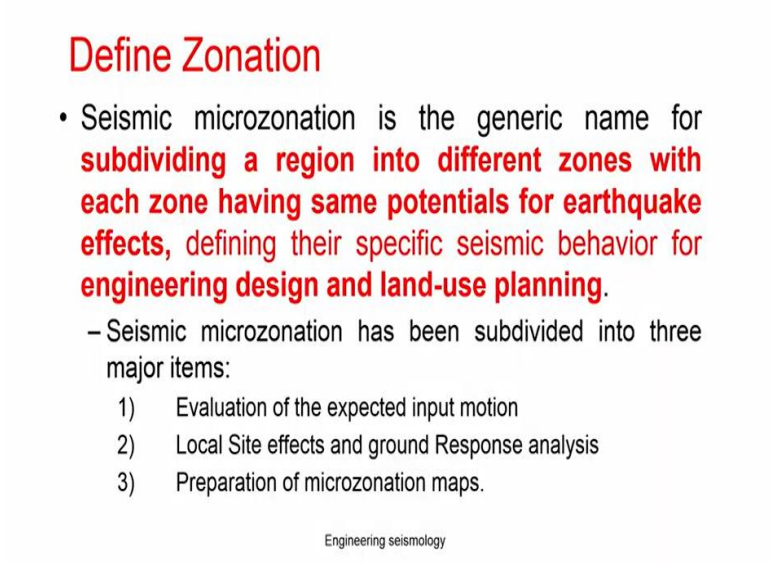

So, the seismic zonation okay seismic microzonation is a generic name subdivided into different zones with each zone having some same potentials for earthquake effect. So, subdividing the region into different zone with each zone; having the same potential for the earthquake hazard. That means if you mark some areas as a zone X okay the X will have the similar seismic effect that was the message which you have to see that means if there is a difference in the earthquake effect it has to be divided as a different zone okay.

So, defining that a specific seismic behaviour the engineering design and the land use planning can be taken up okay by knowing the seismic behaviour, engineering design and land. So seismic microzonation has been subdivide into three major component one is the evaluation of the expected input ground motion at bedrock level. Local site effect and ground response analysis how the wave changes due to the local material at that particular place and then prepare the map which shows this as well as this in the mapping form okay like this.

So, like this it is showing the mapping form this is the process of seismic zonation as we are seen that the older procedures and methodology is looks very complicated and the scale what they do also very vague. So, India okay India has a seismic zonation map which we will be discussed in the later classes in detail okay how the current Indian seismic zonation map is there. So, part of during my research as well as the studies I found that the seismic zonation concept okay practiced in India is not appropriate.

So, I come up with the new methodology for the seismic zonation. So, this methodology only now being adopted in the country for preparation of microzonation of several urban cities

okay in India okay this methodology what I developed this mythology I developed considering all the aspects which affect the earthquake. Because if you see the country level or microzonation they say that only consider seismicity and geology so what about the geotechnical what about the liquefaction.

So, all those things are not included there so in order to overcome all those things I prepared a methodology which is irrespective of the region one can adapt okay depends upon the region what are the steps they can follow? And what are the parameters they can estimate? Finally, you will get your map which shows a hazard index value or hazard value as representation at this particular place that if it is done throughout the country.

Similarly, for all the region merging up all of them you will get a proper seismic zonation map of India okay. So right now, zonation map of India does not consider the systematic analysis of the existing data and the state of art knowledge available in the engineering seismology that is a reason this has been practiced okay.

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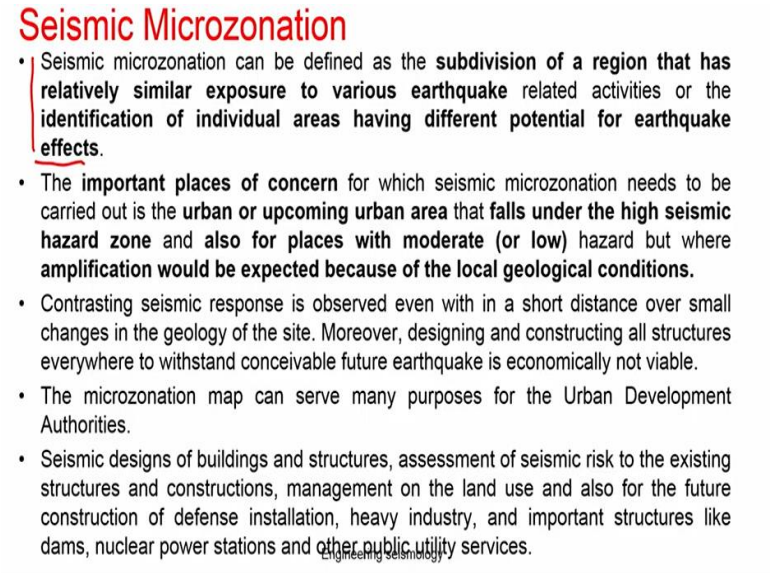

So, if you see that the seismic microzonation is actually; can be defined as a subdivision of the region as relative similar exposure to various earthquake related activities or identification of individually area having different potential of for earthquake effects. So, the seismic zonation map basically should show some earthquake comes how they will affect that area okay how the earthquake will respond to the area.

So, wherever the similar response and effect are there that area can be kept as a single zonation number. So that means we will have the different zonation value at same city. So, the important places concern for which seismic microzonation need to be carried out is a urban or upcoming urban area that falls under the high seismic hazard zone and also for the places where the moderate or low hazard but where amplification would be expected because of the local geology.

So, the seismic zonation has to be taken up for the places where many people are living that important basis of concern okay so that is why India is, they are doing for the most of the urban settlement where the population exceeding 5 lakhs okay. So you can see how many cities we have with 5 lakhs because those cities actually in a seismic zonation present Indian seismic code clubbed as a single zone they did not consider a soil variation in that liquefaction a process in that which is also important then hilly area again landslide phenomena and tsunami in the coastal region.

So, these parameters not gone into the present code zonation map that is why the zonation map has to include all of them okay so where this is with respect to bed rock level as well as surface level. So, depends upon the complex geological formation the seismicity experienced in that area and then those things to be clubbed together to get here zonation identification of the area that you can do the zonation map.

So right now, India decided that based on the population this almost like I think 38 cities has been selected for seismic microzonation work. So you can google it MOS ministry of earth science microzonation work okay in that 38 city already 4 city, 3 city work was 4 city work was awarded 3 city work was actually awarded to the company whose is academically interacting with me okay like Second they are doing the microzonation of Mangalore, Coimbatore and Bhubaneshwar.

So, I am the academic partner where I am helping them to get their microzonation work done experimental work require for that done properly. Now that other city is Chennai which is awarded to the Figaro so they are doing other team. So recently that is 8 more city has been awarded that is awarded to the ISR okay international seismology ISR okay international seismology research centre okay ISR Gandhinagar is there.

So, they have got actually 8 cities where they will be doing for the other 8 places for the microzonation work. So, this microzonation work requires a detailed understanding of all the aspects required or cause a harm to human being. So, the contrasting seismic response observed even with the short distance the small changes in the geology of the site moreover designing construction structures where to withstand consecutive future earthquake economically not viable.

So, this seismic responsive the negligible or it is not very high we do not need to worry too much about the microzonation concept itself. So, microzonation map can settle many purpose okay urban development authorities okay so seismic design of building structure so what are those; where the assessment of seismic risk of existing structure and construction management of the land use for other future construction and then defence installation heavy industry important structure like dams nuclear power stations and other public utility services.

So, the seismic zonation map can be used to design a new building the values obtained seismic zonation studies can be used to design a new building and the retrospect a existing building so that you will avoid damage due to any future earthquake. Apart from that asses how much risk we are expecting from this? How many buildings are going to collapse? How many buildings going into partially collapse if this building collapse how many people will die? How many economic losses okay how many fatalities?

So those kinds of modelling seismic vulnerability and the risk assessment also need a zonation input okay. So then the land use planning and management so locating important facilities okay so the important buildings so all those things we need a seismic zonation map and then the construction of defence installation heavy industries important structures okay all these planning are there then dam and nuclear power and other public utility service where to be placed. Okay how that area is safe so all of those okay can be decided based on the; your seismic zonation map which is systematically prepared.

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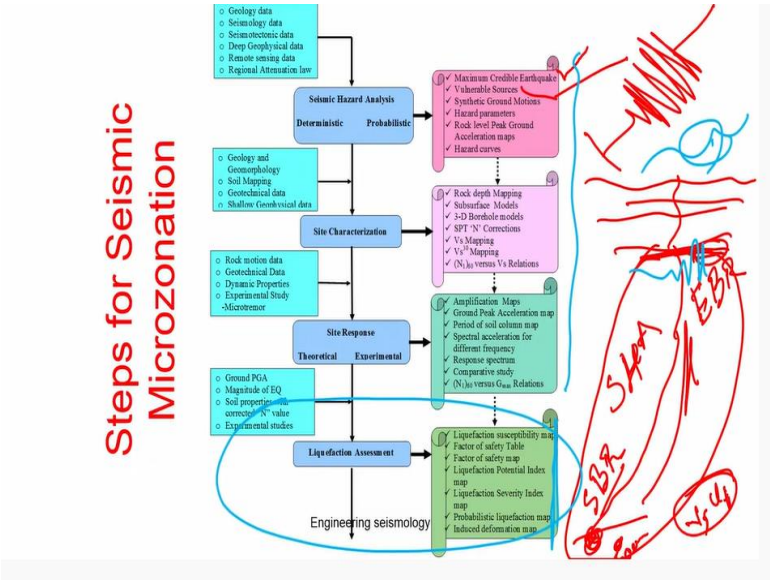

So, as I so I would say told you that seismic micro zonation of India okay is not done and the zonation map during 2007 okay 2004 when I started my PHD so the zonation map of the country also not up to setup part knowledge. So, anyway we will be discussing about the Indian seismic code in the next class so that time we will understand how Indian seismic code so what is the state of knowledge gone into that so that it will be easy to relate to what I am talking now.

So, by considering all this is; by understanding seismic hazard different level where it affects people a systematic procedure has been developed that is called as a methodology for microzonation and steps for seismic microzonation for any area. So, this is a universal step anywhere can be adopted under any scale okay this is nothing to do with the scale because the previous method what suggested it is actually confined to that level okay scale or grade.

So, here I say that you do scale depends upon the your funding availability but you try to consider all of them systematically for example if you have the better funding you can go for the lowest scale 1 is to 5000 1 is to 10000 if you do not have the spending you can go for the 1 is to 20000 1 is to 50000 depends on that. So, the microzonation process has been divided as a 6 major and then finally integrating one step 7.

So, the first and foremost step is basically to get earthquake hazard analysis at a particular location. So, in our course you will be discussing only the earthquake hazard estimation only. So, beyond that actually you need a civil engineering background knowledge which we are

not going to discuss maybe in the future I may offer a course on NPTEL itself on the other part that is any way future but right now we will learn it.

So, but I will discuss the detail the steps because why it has to be taken care and how it is be taken care. So, the seismic hazard analysis and the estimating the hazard bed rock means; so basically, as we discussed that earthquakes are happening in that. So, but this is your site okay so then the waves are this is a source so now we understand that what is the source and order waves are moving as we are seen that there is a continuous soil layer.

So, this reaches we are basically calling it as a engineering bedrock which we have discussed this is the seismic bedrock okay this also we discussed so the hazard estimation okay the first step taking care of up to this part this is the first part of seismic hazard analysis okay. So how it will take care basically we have to characterize this measure this property well and know this property well and then estimate what is the hazard at this level reliably okay.

So, this can be done okay by looking at and the studying a geology data on the region okay. So, your input will be a geology data second seismology data means your earthquake record earthquake history so okay all those things. So, then the even the intensity maps so those are all the seismology data. The another one is the seismotectonic data so seismotectonic data means the data which is obtained or which gives a source location source parameters deep strike angle which we are discussed okay fault length okay the fault orientation.

So, all those things are seismic then the deep geophysical data where which gives a your Vp and Vs, Vp and Vs value at that particular place. So, we have seen that these values are useful to model okay to simulate synthetically ground motion data. So those are; apart from that you should also look at a aerial data okay like remote sensing; remote sensing data to see how the area is geologically geomorphologically different okay. Then the ground motion prediction equation or attenuation relation.

So these are all the input which is required which you can obtain the by going through literature and also carrying out some of the experimental studies for example the source activity can be identified by taking up a active fault study which you have seen deep geophysical studies and all those things. So, once you get all this information so you can do seismic hazard analysis by deterministic or probabilistic way.

So, the deterministic or probabilistic way we will discuss in detail in part of our class which we are going to teach you part of this course. So, once you are done that then finally you will expect some of the output from this method one is that what is the maximum possible earthquake in the region? Like maximum credible earthquake. Second is so what are the active sources and vulnerable sources and if this earthquake comes how your acceleration time will look like.

So, these are synthetic ground motion as you told that some of the analysis you need a time series analysis you need a synthetic data so that okay then the hazard parameters in terms of PGV, PGD, PGA and then the duration and the intensity those are all the hazard parameters. So, these values are basically recorded okay or estimated at bedrock level okay. So, we particularly the rod level peak ground acceleration which is one of the important inputs for the engineering requirement we are seeing that the zonation map has to give you the PGA distribution peak ground acceleration distributed in the region.

So that map preparation should be then the hazard curve when you do a problematic hazard analysis okay you have to produce what is the recurrence rate on a given time and period reliability and then the probability okay that kind of hazard curve. So, this entire part is unique irrespective of the region. All the; region this has to be done okay so the ones you are done that you have to make the hazard to propagate surface.

So in that case okay so making this part basically so you have to basically see how the waves are propagating if you want to see how the wave get modified on due to the local site effect first you have to understand what material is there what properties dynamic properties static property as we are seen that the wave propagation controlled by the constraint and the sheer modular density Poisson ration that has to be estimated that process is called site characterization.

So, in that again you look at geology geomorphology and soil map by drilling a bore well and soil strength estimation in the form of Vs value, SPT N value okay then shallow geophysical survey. So shallow means you will concentrate up to the bedrock level not go very deep those kinds of study has to be taken and the; those data is a input and then you do systematically characterize that place based on the this property estimation like rock depth mapping.

You prepare subsurface model you develop how the bore rock thickness soil thickness varies 3D bore rock bore models and SPT N corrections which is required for the liquefaction assessment Vs mapping Vs30 mapping and N versus Vs relation so that some places where it is not possible to measure Vs you can use existing Bore rock data. So, for this purpose even you can collect bore rock from different places and use it as long as the bore rocks are reliable.

So, this site characterization itself a class which cover 3, 4 hours but this is not part of our scope okay so only up to hazard analysis we will stop these courses. So, later stage if you are interested, I teach this course for our M. Tech and PhD students or in case I offer the course for you then you can understand how the site characterization is done. Right now, we are going to demonstrate that so once you are done that okay this is your characterizing their properties in their materials here.

Then how the waves going to modify because of this material? That analysis called as a site response analysis. Okay the site response analysis can be done theoretically by experimentally so the input arrived from these two methods okay so this one and this one go as a input here because you need a bedrock earthquake level hazardous level and then the soil property then you estimate what is the modification happens? How you quantify that is the output you get so basically how the waves are amplified.

So the amplification map will be generated then how the peak ground accelerations are modified at the ground surface okay how the period of soil column changes okay the fundamental natural frequency of the soil column spectral acceleration for the different frequencies response spectrum design spectrum okay so then the comparative study of different approaches and the reliable result you can obtain.

So that is obtained in the step 3 of the zonation process microzonation once you are done that so now you know that the; we have estimated the ground motion amplified at the ground surface okay. So but as I told you that this amplified ground motion if the soils are cohesion less particle it causes a liquefaction or soil failure that has to be assessed why because even if we consider the design force for this your structure if the soil is liquefy the structure will go inside okay it is sucked inside and it fall okay the structure may be intact but the building may fall.

So that kind of problem is comes that has to be accounted that is why the liquefaction analysis should be part of that microzonation. So, for the again here you study the details what you obtained from the last two three steps will be clubbed together so that is why you can see basically I have been marking a arrow continuously you can see. So, each one is linked and you can also see the output from each one is coming as input to other.

So the liquefaction what is the surface amplified acceleration which is obtained here the magnitude of earthquake which is obtained the controlled magnitude soil property which is obtained steps 2 and then you do a detailed liquefaction analysis and try to prepare the liquefaction susceptibility map and factor of safety table and factor of safety map and liquefaction potential index and susceptibility map finally you will say that delineation of liquefiable non liquefiable area.

Liquefiable area how much ground deformation causes. So those are all the output will be produced from this step. So this is a very important step particularly when the regions have the cohesion less soil non clay soil. Those kind of places liquefactions are important so you can see that first 3 step is important for almost all the region this is only applicable to the region where the cohesion less soil is if there is a clay soil you do not need to worry about the liquefaction. Okay but you have to check it as a liquefaction is possible or not.

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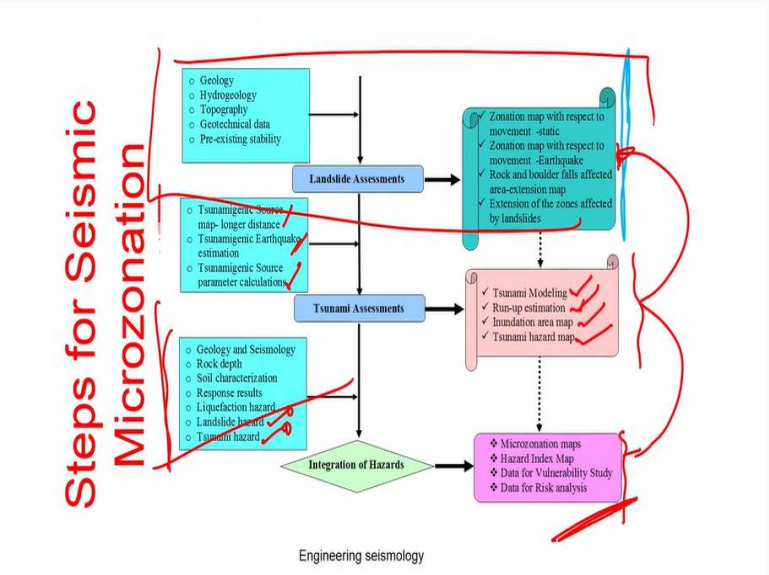

So, once you are done that so as you know that in the land area even though your site base, we have the liquified soil houses are there but your foot of the hill then the hill slide will

collapse a house it will damage house. So that means you have to assess a landslide in this region to prevent the land collapse or mass soil moment in your region. So that landslide requires a land slide assessment parameter such as a geology, hydrology data topography and geotechnical data and the pre-existing stability existing.

So, this will be used to assess a potential landslide possibility and prepare a landslide zonation map with respect to static condition static condition no earthquake dynamic condition with earthquake okay. So how much mass of land will move? How much it will displace? What is the force we expect to your house? Okay those are all the parameters should be assessed here this is only applicable to the only region with where hill is there not all the place.

You may be settled in the valley okay but they you should consider that your upstream side or other nearby area you have the hill which will affect you, you have to check on that. So once that is done okay the coastal area as we have seen that the tsunami is one of the major concerns where 2004 lot of people died due to tsunami so you need to consider a tsunami assessment.

For the tsunami assessment your seismic study area okay or the study area what you can consider? You should go beyond the damage level. For example, as I said that Indian earthquake North India the damage is caused up to 750 kilometres south India up to 500 kilometres based on the isoseismic map which is available. So, the tsunami you have to go for the 2500 kilometres why because as we have seen that the Sumatra earthquake which is roughly 1500 meter and the kilometre and above caused tsunami.

So, in that case any tsunamigenic sources located more than 2500 kilometre or up to 2500 kilometre need to be accounted for the tsunami assessment for that region you are to prepare a fresh map of information which is called as a tsunami geonic source map for longer distance okay. Then tsunamigenic earthquake estimate what is that? Earthquake which causes the tsunami, tsunami source and the parameter this the information you should collect and do the tsunami hazard assessment and prepare a tsunami modelling runoff estimation inundation map tsunami hazard map.

So this is will be your output from this so now at any given region depends upon the where it is located you could able to assess all the parameters systematically I did not discuss each parameter in detail that is like a separate subject each one will be taught more than 3, 4 hours okay. So that is generally I do it for the M. Tech and PHD students in IISc. So those were interested to know about this maybe in the future I can offer this course also some time okay.

After doing everything what you should do you take all the output as a input here okay like seismology, geology, site response, site characterisation, liquefaction, landslide and then depends upon the city you can assign a weightage okay. So then for example if we are doing a microzonation of Bangalore okay there is no tsunami there is no hazard. So, you can make zero zero liquefaction may be possible rest of the.

So you can assign a weightage and integrate all this hazard using analytical hierarchy procedure finally develop a zonation map that zonation map is a complete zonation map this map consist of all the input whatever output whatever discussed in each step so that the engineer can get PGA distribution map or design designer will get hazard index value for getting the this one.

So, this map basically gives you a data which will be useful for future risk assessment, vulnerability assessment, exposure knowledge city planning and development such kind of maps are called as a microzonation maps. Okay this can be done irrespective of the scale but all the parameter has to be assessed at some level you cannot skip some of them only you should skip if it is not valid.

For example, if you are doing the microzonation of some city in the Himalayan region okay where hills are there so tsunami may not come that you can ignore it okay. So but landslide should be part of that if you are doing microzonation of some city in south India where there is no hills are there then you should remove the landslide part and if it is not coastal area you can remove the tsunami part but the rest of the step has to come.

So, you can see that the first okay so the 3, 4 steps are essential component of each micro zonation the fifth and sixth one are the region specific. So only the hilly region this will come okay the coastal region this will come okay. So, the tsunami will come on the coastal region

so both integrating all of whichever is applicable integrate and finally produce a zonation map which shows a different zone okay.

1, 3, 4 so depends upon that this analysis. So, in our class we are going to discuss how to do seismic hazard analysis which is the first part of zonation or bedrock level zonation map because other part we need a geotechnical engineering knowledge which is generally I am not given us a basic requirement for this course and also if necessary I will be taking us that as a second level like next level engineering seismology course 2 or something like that so that time we will see.

So now we understand how the zonation map should be prepared okay what is the methodology available next class we are going to see what is our current zonation map does your current is zonation map consider all of them or not that discussion we have. So far whatever we discussed actually generalizable procedure which is applicable throughout the world. So, hereafter what we are going to discuss which will be very specific to India because we will be talking in terms of application side.

As I told you that we are going to talk about the application side so we will be discussing about the Indian seismic zone map in the next class followed by the Indian seismicity and then how to estimate seismic hazard by considering the different advanced methodology and how we can do the systematic hazard analysis so that you can prepare a PGA distribution map at the bed rock level using seismic hazard analysis that is not a zonation map but at least that is a basic component of the zonation map. That we will be discussing in the next class. So, with this I close this lecture so thank you very much for watching this lecture we will meet in the next class. Thank you very much.