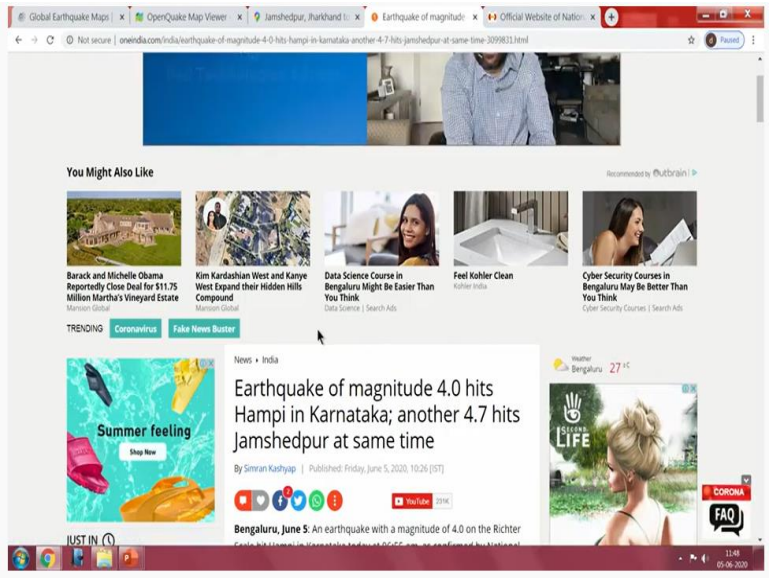
Introduction to Engineering Seismology
Prof. P. Anbazhagan
Department of Civil Engineering
Indian Institute of Science – Bangalore

Lecture – 41
Seismic Zonation and Microzonation

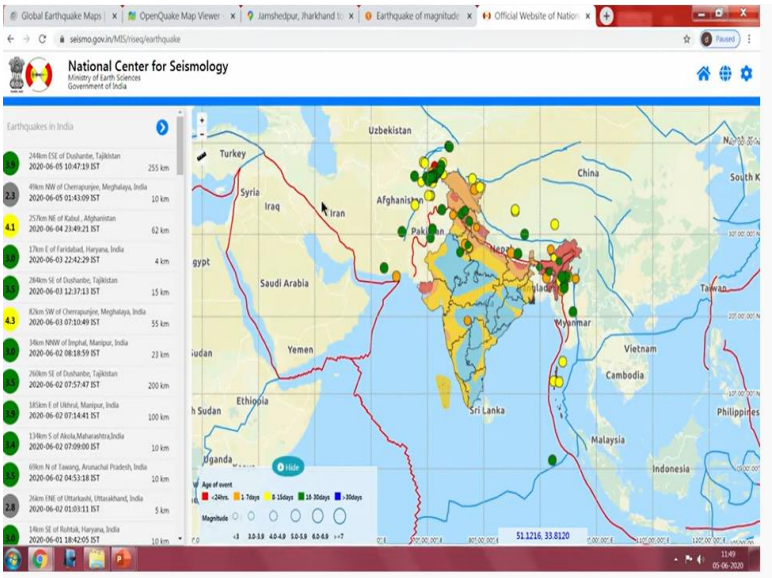
So, vanakkam; so we will continue our lecture so on the engineering seismology. So last class we have been discussing about the Earthquake prediction and we told that it is not possible to predict earthquake 100% accurately okay. But there are some precursors which you can use to tentatively predict the earthquake particularly if you match 2, 3 methodology continuously and then you can reliably predict a earthquake but it is not many cases fails because of the incorrect location incorrect time and the incorrect size okay. So, these are all the some of the issues and so during this class discussion on today so there was also news okay so which you can see in the screen actually. There are live web news actually.

(Refer Slide Time: 01:06)



So, you can see that the earthquake of magnitude 4 hit Hampi in Karnataka another 4.7 hit Jamshedpur at the same time. Okay so it is a news says that there was an earthquake okay on this magnitude and hit at Hampi and as well as in the Jamshedpur. Okay so I am not very sure that how far these earthquake reports are right because many times since there is poor seismic instrumentation and then the many vibrations which caused by any other human activities are to be considered or people believe that that is earthquake.

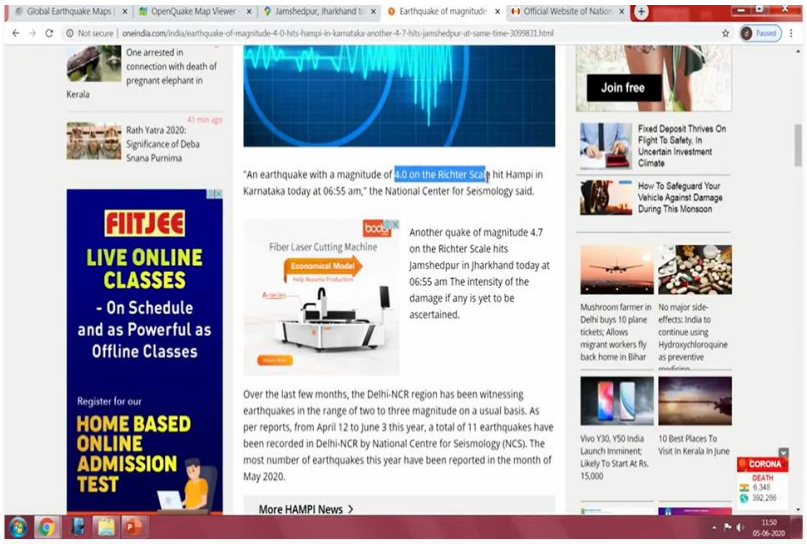
(Refer Slide Time: 01:58)



So, let us see the IMD website official website this is actually Indian meteorological department website. So, what was the last update was given was that actually about okay so this was today morning okay so not; yeah today morning 10.47 was the last update so if you see the different earthquake which is reported basically. So, there is issue with the screen, I think I can reduce the size okay so now it is possible to see okay.

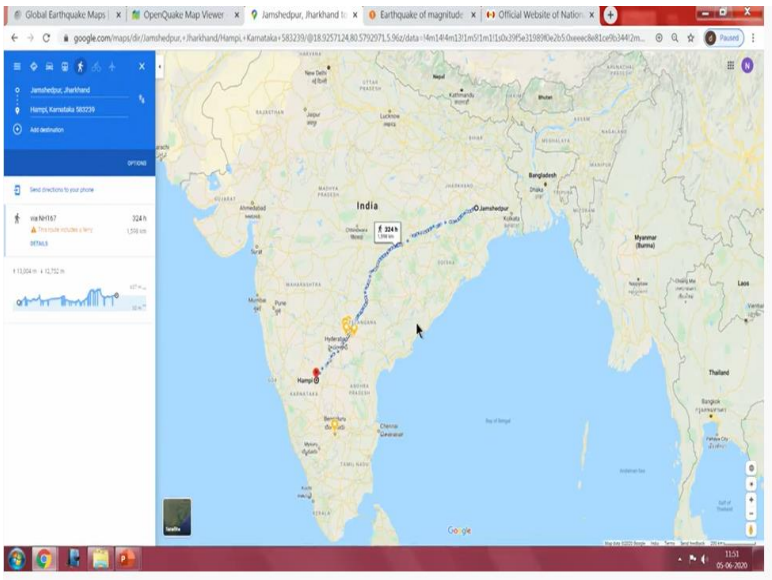
So, there is one earthquake Cherrapunji Meghalaya there was a earthquake. So, it was around 01:43 early morning so that report what we have seen okay it shows that there was about 6:55 in the morning there was two earthquakes, one at Jalandhar not sorry Jamshedpur and another was in the Hampi. So, I am not very sure there is no such any records are reported here okay. So, there is no such any records are available.

(Refer Slide Time: 03:05)



So maybe I think this we have to check really check the seismological data. So, you can also see that they are given a Richter scale 4 on Richter scale and timing another is magnitude of 6.4 on Richter scale again they have given. So, since the sizes are very small so the Richter scale will be more accurate. So, but again that is your doubt whether it is earthquake or not which maybe you can explore. Okay so because right now I am not very sure I can comment about that without seeing let us see the geologically where this area is located.

(Refer Slide Time: 03:37)



Actually, this Hampi is located on this place basically this is Hampi most of you may be knowing it is almost like a centre of the Karnataka even a southern India you can say. So, the Jamshedpur is here it is here somewhere. So, both regions actually in the peninsular India but the both of them very far okay so there is about 1600 kilometre far roughly okay. So, 1500 kilometre roughly far.

So I am not very sure that is anything linking between these two one can expect that the earthquake maybe happened kind of things anyway you can explore that what happens and about this report and by the time it will be clear today or evening tomorrow there will be officials there will be issuing the warning or notice saying that it is true or false kind of things and we also should remember that what are the seismic station nearby in case we have a seismic station very far.

For example, if there is no station around 100 kilometres from this region it is very difficult to record a lower magnitude okay. So that is also one of the factor we should consider it does not mean that all IMD website reported is right because we are seeing that they have station

capacity at different part of India depends upon their radius zone and instrumentation type and all which you nearly we have to consider okay.

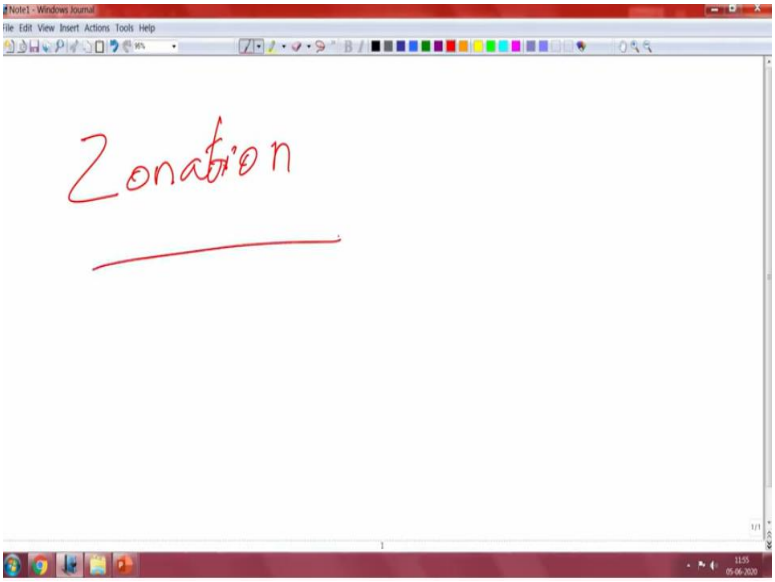
So, let us get back to the business okay so what we have been discussing actually the earthquake hazard prediction okay because earthquake prediction it is not possible but the earthquake hazard can be predicted. So, why we need to predict earthquake hazard and how it is represented. So, as I told you that even though this prediction okay so the prediction will help you get to get some of the information about the earthquake but that will not help 100% reduce your damage and loss due to the earthquake.

So how do you reduce the damage and loss due to the earthquake by proper prediction and mapping up earthquake hazards. So, how do you map and the predict earthquake hazard so that is what we are going to discuss in the couple of classes from now. As we have seen that okay the time domain and frequency domain parameter duration these are the important parameters which require.

So, estimating of this based on the past earthquake will help you basically to design your structures for the future okay. So, even a past data will be sufficient at least to avoid a collapse of building. Okay that is what you can see if there is a known history of earthquake in the region will be sufficient to consider to avoid a collapse of the building if we want to go for more accurately you can predict hazard for the future.

So that is the prediction of earthquake hazard. So, this earthquake hazard prediction not everybody can do because you need a scientific knowledge and background and then analysis skill so because of this okay so there is a agencies okay or a institution which is controlled by the government okay a government set up a committee to do this process and release a map okay. So that kind of map is called a seismic zonation map okay.

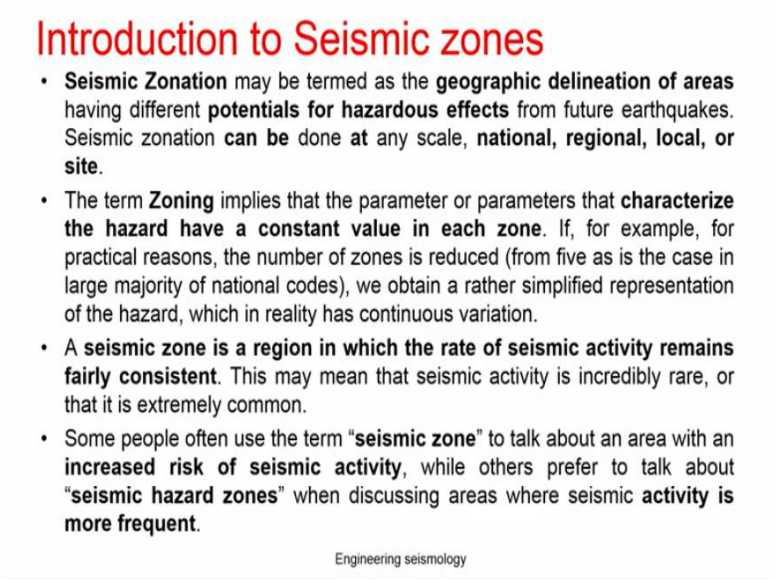
(Refer Slide Time: 07:12)



So, the seismic zonation, so okay this zonation is basically grouping the area okay by similar seismic activity. The seismic zonation means you preparing the map okay so showing the seismic potential of the region okay. So today class we are going to talk about what is mean by zonation our different level it is done okay what is the correct way of zonation doing the zonation we are going to discuss in the today class.

So, I say told you that since earthquake hazard prediction is not possible for all the level of earthquake. So, it is better to go for the predict hazard throughout the country and inform to the people okay then so that people will consider that for the design in this one. So, the process at which where the preparing a map kind of things about the different earthquake hazard parameters is seismic zonation and the seismic microzonation so we are going to discuss about that.

(Refer Slide Time: 08:17)



So, the seismic zonation maybe term geographically you are dealing in the area having different potential for the earthquake hazard effect. So, earthquake hazard effect so what are the earthquake hazard effect we have seen? We have seen that the ground shaking is one of the earthquake hazard effects. So, telling how much ground going to shake so ground shaking can be represented in the time domain parameters of acceleration velocity or displacement or duration.

So, these kind of parameters mapping them and telling in the geographical form and delineate the similar values call it as a single zone is called as a seismic zonation. So seismic zonation can be done at a different scale okay national level, regional level, local level and the site level. So, what is the national level? The entire area of India can be considered as a seismic zoning area you can adapt.

So, when you consider larger area the minor information what you are going to consider will be reduced. So that kind of larger area is a national level hazard prediction but the larger level hazard prediction may not be very accurate sometime the variation in the geology and seismotectonic and seismic wave propagation at a particular location will be missed. Okay so, that level the regional level zonation like a district okay state those are the regional level seismic zonation.

So even if you do the regional level seismic zonation that may miss some of the issues for example the entire Karnataka state okay so the south Karnataka like Bangalore, Mysore this falls on some geological formation. So, the north Karnataka Hampi and other place this falls

on the different geological formation. So that case so that local level variation may not be even accounted in the regional scale.

So that to account you can go for the local level okay say like microzonation of city or zonation of city kind of thing and the site level okay so like within a Bangalore so IISc camp okay The IISc campus and then the electronic city may behave differently because of the structure rather than the geological formation and the people in that area building type so this is to be considered site level so that kind of variation will occur.

The term Zoning implies that the parameter or parameters that characterize the hazard have a constant value in each zone. So, you can group them into different zones and then wherever equal value that is a single zone. For example, for a practical reason the number of zones reduces five as in the case of larger majority of national code may we obtain a rather simplified representation hazard which in reality has continuous variation.

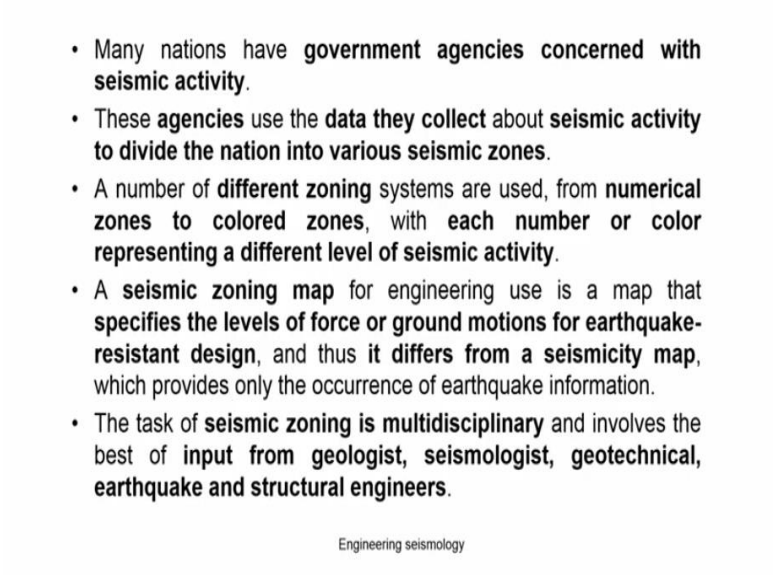
So that you should delineate means you should not delineate with 25 zone 20 zone it should be minimum number okay generally five is the common smallest and biggest number they adapt for the zonation purpose throughout the world okay. A seismic zone is a region in which the rate of seismic activity remains fairly constant. So, if somebody says that the two three area in the seismic zone okay is number same zone it relatively behaves a same manner okay.

A seismic zone is a region in which the rate of seismic activity remains fairly constant. So, this means seismic activity increasingly rare and extremely common. Some people often use the seismic zone to talk about the area of increased seismic risk activity. So, seismic zone is different from the seismic risk okay. So, for example people believe that India we say that India is actually four zonation right now.

So, the highest zonation in the Himalayan belt region okay so people believe that because it is very active and high zone they think that is a seismic zone and the Bangalore which is seismic zone two they believe that is Bangalore is not a seismic zone because they interchangeably misunderstand a seismic zone and the seismic risk okay. The highest zone will have the highest risk okay if the people have prepared for that it may have the lowest risk.

It does not mean that you should always have the highest risk the lowest zone may have the highest risk or lowest risk it depends upon the people preparedness construction and the magnitude of earthquake place lot of things which covers which we have discussed all the wave of propagation all those things. So, people will interchangely use but here after you should not have that kind of confusion the seismic zone means zone which represents a seismic hazard in that area okay the similar exposure of hazard in that area that is the seismic zone.

(Refer Slide Time: 13:15)



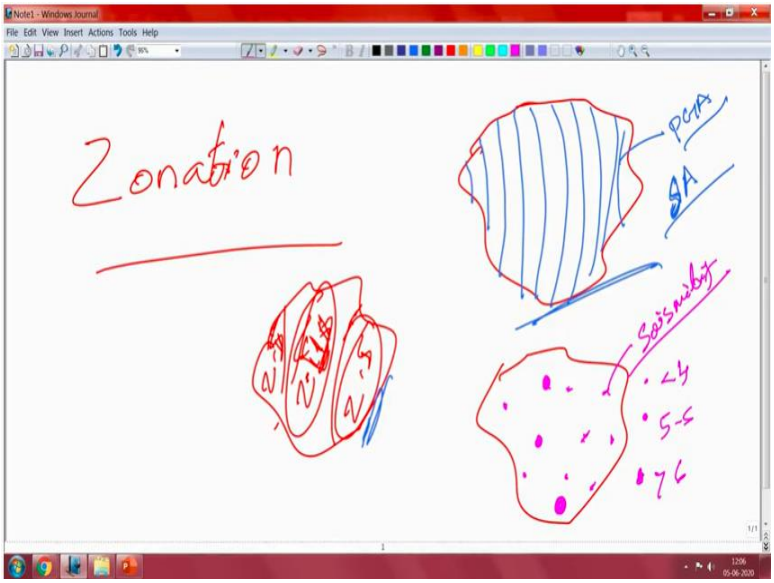
So many nations and government agencies concerned with the seismic activity because as it is not predictable many people die, we have seen that the lakhs and thousands of people die every year due to earthquake it is irrespective of the develop the economic status and education all those things. Only thing we observed that the developed countries damage will be 1% lower than the damage caused by the developing countries okay so that was we have seen that is due to the preparedness and structural resilience all those things.

So, the government generally will concern about that so they prepare a zonation map and tell people that this is a zonation of the country you design your building and take care yourself to live in this area okay. So, these agencies uses data as they collect from the seismic activity divide the nation into various seismic zone. So generally, the government involved are preparing seismic zonation map yeah, a number of different zoning system are used from the numerical zone to the coloured zone each number and colour representing the different level

of seismic activity okay they use a numerical number or roman number and with colour coding.

The seismic zone for engineering use is a map that specifies the level of force or ground motions for earthquake-resilient design and thus it differs from a seismicity map which you provide only the occurrence of the earthquake okay. So, here we are going to differentiate the seismic zonation map okay then seismic zoning map what engineering is looking for okay seismicity map okay.

(Refer Slide Time: 15:20)



So, if you look at the different map okay so as I told you that so this is my area okay so I can prepare a different map okay. So one is that I will make this area divide as a different zone okay zone 1 zone 3 zone 2 okay so this is a zonation map because it implies the seismic zone equally behaving area sir given okay so this is the seismic zone map so the same map this can be generally useful to know that which area is more dangerous as per this map the area zone 3 is more dangerous then zone 1 okay that is the 1.

So, but the engineering people may not be knowing the more or less it only common people use okay so somebody want to start a business okay so then he will try to prefer places where less risk okay that is the one thing. Or somebody wants to set up a chemical factory okay so that is government will choose a land for selecting them so they go for the less risky area okay like that is still useful.

But engineers may not be only convenient with that because they need a seismic values hazard values which is useful for design of structures in the. So, what are the ways you can consider the hazard value? So, time domain parameter frequency domain parameter like you need to give a PGA peak ground acceleration or PGB or PGD or the spectrum acceleration with the time that is what we are seeing spectrum.

Okay so these two parameters it has to be mapped and given as a zonation. So that is what engineering record map okay that is a zonation map but these two maps should not be confused with the seismicity map? What is the seismicity as we have seen that seismicity is spatial distribution of past earthquake? For example, somebody say that seismicity means okay so they can say that so here I will give you a ledger.

So, this is like a less than 4 so 4 5 to 6 okay so this is like more than 6 something like that. So I am representing the seismic history of the region or seismic event reported in the region this map is called seismicity map. So, people should not confuse it with the seismicity map with the seismic zonation map seismic zonation map may not a seismicity map okay but seismicity data may be useful to arrive those zonation but seismicity maps are different.

So now you understand what is the seismic zone? What is the seismic risk? What is the seismic zone required by the map required by the engineers? And what is the seismicity map? So, this is the made you very clear to understand the earthquake related activities or earthquake related zone okay. So, there should be clear understanding between this maps so let us see so the task of seismic zoning is a multi-disciplinary activity which involves the best input from the geologist and the seismologist geotechnical and earthquake and the structural engineers.

So, the zonation map of okay any place should be prepared by consulting all these people why you have to consult all these people. So, we have seen that geologists know to do a seismic source in the region okay that is what seismic source characteristics source related study will be obtained from the geologist. So, the seismologist basically gets a fast earthquake data in the form of isoseismic map or earthquake recorded data.

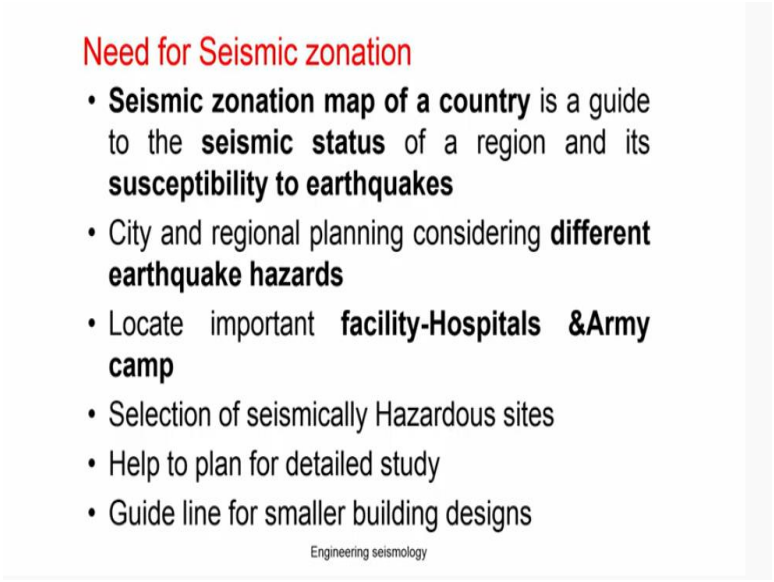
So, the geotechnical engineers okay so the engineers will basically try to understand when wave propagates okay how the different layers of they are going to behave. So that is why the

geotechnical engineers are very important. So, the other earthquake engineers basically will try to estimate a hazard okay so and try to predict the probability of occurrence of that data that is why earthquake engineers are important okay.

The other engineers' structural engineers all this data whatever you do how the structural form. How we can consider these forces to reduce my structural failure so that is what structural engineer does. So, all these people together should work okay or the knowledge of all this information should be gathered together and incorporated in the preparation of seismic zonation map.

So, the preparation of seismic zonation map is a very important part as it gives useful data for the future settlement and then disaster management and lot of things okay. So why we need a seismic zonation map?

(Refer Slide Time: 20:58)



So, the seismic zonation map of the country is a guide to show the seismic status of the region and it is susceptibility to earthquake. Okay by knowing the seismic zonation one can believe that we are living in the high-risk area, low risk area intermediate risk area whatever. And how this area is susceptible for them to act like by knowing those zonation you can know that zonation's are very high.

So, there is a more possibility of getting the higher magnitude of earthquake under seismic forces or seismic events in the particular place okay. So that is the information we will get and this city and regional planning considering the different earthquake hazard. So, city

planning and regional planning, so, the planning state okay we need to know some of the facilities where to get. So, what is the city planning?

So generally, in India city not planned actually with the time city are growing that is all there is no planning kind of what is the city planning? For example, in particular city where that I should keep secretary the office secretary office like government secretary where I should keep to locate a hospital where I locate a police station where I locate factories okay particularly hazardous factors like chemical factories gas filling stations okay all of those things there is some kind of deadline.

So you should locate only on those places so that kind of planning okay regional planning it will help okay city planning it will help and then regional level so where I will construct the dam where I will construct a nuclear power plant okay where I will construct a multi-speciality hospital with a larger scale and population. Those kind of information will be city and regional planning.

So as on now in India I do not think we go by anything so how the zonation map for example the seismic zonation map are prepared for the Bangalore okay. So as such we already have station, hospitals are located I am not talking about that we are going to do so by looking at this map okay so this region the entire Bangalore region is basically divided as 3, 4 zones okay like this okay there is one zone one zone then another zone something like that has been prepared okay.

So, this will be the zone 4 zone 2 okay so zone 2 and the zone 3. So, the city planning means generally the emergency services okay or the very important services what are the important services at any cost the administration government should work. So the secretary facilities that is very important at any cost law and order should work so those are all the things that are very important at any cost communications should work those are all the things are important activity at any cost fire things all should work at any cost hospitals should work.

So these are other important facilities by planning the city you can try to avoid high risk zone we can try to avoid this so you try to move this place this place it is not depends upon the people depends upon their seismic risk okay you should locate accordingly okay that is where you will. Secondly like transportation system like that so you can scale up the facilities and

importance for example the army camp at any cost the army camp should not be suffered due to earthquake.

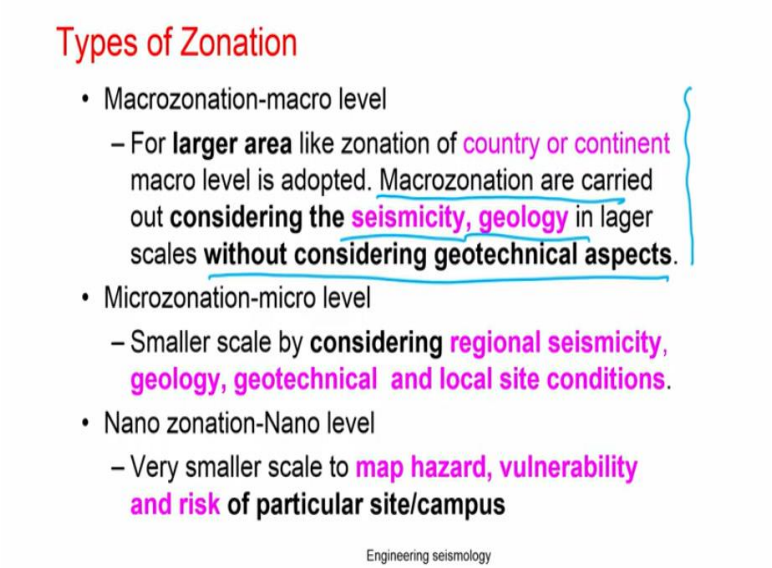
So you should locate them in their safer places okay so that kind of planning will help okay this kind of learning will help then the hazardous sites means like a nuclear disposal site chemical factories okay the gas filling station this should not be kept where in high risk area because sometime if the earthquake occurs in these areas this causes a fire flood unnecessary issues which is worser than the okay the actual earthquake itself.

Because that kind of things will be minimized okay when you do that this kind of this one and then the seismic zonation map also should do provide input for the design of normal buildings in that region. So not special building I am saying normal building because the country level or regional level or city level mapping considers a large area you cannot confine the small variation.

So, in that case a normal guideline for the routine building. So routine building means that ground plus one, ground plus two something like that the special buildings especially building means like 1000 people 2000 people stay in that same place okay multi-story apartments then the hospitals okay then the chemical factories. So, these are all the special buildings that your sites specific condition has to be considered to design okay.

So those are the area to identification all those should be done in the zonation map for that you need a zonation map to locate and also know that you are in lowest seismic risks to higher seismic risk as well. So, these are all the information where it will be useful basically to get to know from the seismic zonation map. So, this is their importance of the seismic zonation map.

(Refer Slide Time: 26:36)



So, what are the ways the seismic zonation maps are done? So seismic zonation maps are done at different scale and level. Okay what are those different scale so the seismic zonation okay the types of seismic zonation is defined as three major categories okay one is that Macrozonation okay Microzonation and Nano zonation okay. So, this is basically gives a scale so the macro means the zonation which is done at a larger scale okay.

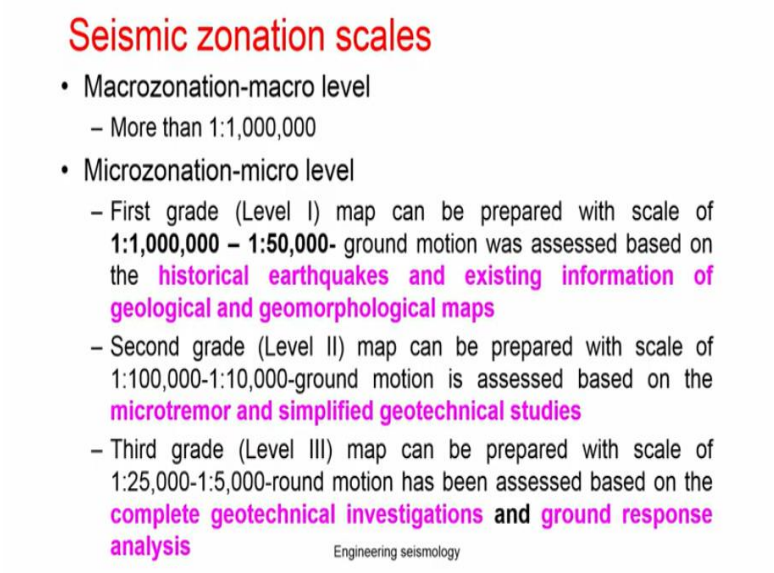
So, by the larger area like country or continent okay the micro macro level is adopted okay so the microzonations carried out considering the size must be a challenge. So, macrozonations are basically carried out by considering the seismicity and geology in larger scale input without considering the geotechnical aspects. So that means the viral propagation considered based on that the approximate geology of the region and the seismicity of the region they will do so this kind of region while preparing the seismic information in India or Asia okay or any Asian continent, Australian continent, America continent.

So they do their macro zonation okay so the microzonation means micro level so where they try to put information on the wave propagation basically the all the damages controlled by the wave propagation that tried to adopt a regional level recorded data or seismicity try to understand how the wave propagations are happened try to incorporate okay the geology geo-technical and local soil condition how it modifies the waves that kind of consideration is given in the Microzonation.

Okay the nano zonation is generally done by the typical area or place like army camp, ISE camp something like that where a confined area for several acres okay those kind of things is

called as a nano zonation very smaller scale map hazard people they even consider a building type and the risk associated with that so that it can be damaged can be minimized considerably. Okay this is the three type of seismic zonation.

(Refer Slide Time: 28:56)



So the seismic zonation is also depends upon the type the scale what they adopt may be actually so what I am discussing here is actually published by the ISSMGE the international workshop people discuss and finalize the scale at which mapping has to be prepared but this is a slightly old actually because now because of the improvement in the electronics and mapping tool and all. So, you can even go for the very low level a lower level scale even for the but the minimum okay so basically a macrozonation will be done considering the scale up one is to ten okay or 1.

So, the microzonation is considered a lower scale okay so then but it is done at the three level what are those. First grade, second grade and third grade Microzonation first grade means map can be prepared at the scale of 10000 to 50000 the ground motion was assessed based on the historical earthquakes and existing information of the geology and geomorphological maps they do not do any detailed investigation or analysis to get the data okay so that was this called the first grade.

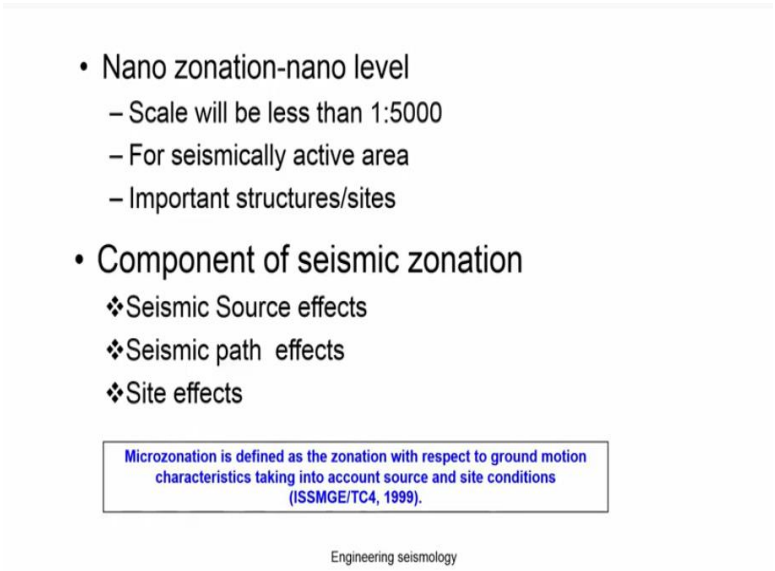
So, the second grade is where they prepared map 1 is to one lakh one is to ten thousand the ground motion is assessed based on the microtremor and simplified the geotechnical studies. So, we will be discussing the microtrauma microtremor is basically so I say told you that the seismic record okay the seismic record you get know. So, if you get your seismic record you

get the recorded earthquake data but in all the places you may not get the recorded earthquake data because the earthquake may not have happened.

So, people scientists come up with the concept that the seismometer can be used to record the vibration at the particular place that vibration can be taken up and used for getting the ground waves how it propagate at a particular place particularly by knowing the predominant frequency of the ground we are seeing the fundamental frequency natural frequency know. To measure those values, the microtremor waves are used okay that is way you should use microtremor and geotechnical.

So, you are not modelling only measuring those scales. The 1 is to 25 or to 1 is to 5000. So, this prepared a scale ground response based on the complete geotechnical investigation and the ground response. So, here they tried to model wave propagation very accurately try to predict how the waves will get changed okay try to predict how the waves are getting changed. Okay how the waves are getting modified or reduced or increased. So, that is the microzonation level.

(Refer Slide Time: 31:42)



So, the nano zonation generally done nano level where the scale will be less than 1 is to 5000 for seismically very active region are important structures and sites. For example, setting up a nuclear disposal site; setting up a nuclear monitor nuclear testing reactor okay setting up a huge dam so these are all the information required a minor level wave propagation at site. Okay, because a dam these sites are few acres okay like maybe a 100 acre 200 acres not a very big level.

So that kind of places you need yeah nano zonation so the component at which their seismic zonation has done basically. So, they try to estimate a source effect okay the path effect and insight side effect okay. So three of them clubbed together under the microzonation defined as yet zonation with respect to the ground motion characteristics taking into account of source and site condition okay that is what defined as a Microzonation which is defined by ISSMGE technical committee for this committee is responsible for earthquake related studies during 1999.

So, this definition okay so any region which divides okay the region into different zone considering the source for site modification or effect and the wave how it is formed is called seismic zonation seismic microzonation depends upon the scale what you adapt. So the microzonation concept is which is the origin for developing; a seismic zonation of each country or i say told you that each country will release their own seismic zonation map okay.

So then that zonation map will act as a input for planning okay then execution construction all those things for normal buildings okay a special building one has to do that own studies we will also discuss about the Indian zonation map what is the advantage limitations in the future classes. So, we will continue Microzonation concept in the next class okay right now we will just talk about what is the zonation okay what zonation must have.

Why we need to do the zonation all those aspects we have discussed. Next, we will see how we can do a better seismic zonation what is the methodology we should adopt in the next class. So, thank you very much for watching this video so we will see you in the next class. Thank you.