Introduction to Engineering Seismology
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Module No # 03
Lecture No # 15
Intensity Scales of Earthquake

So vanakkam, we will continue our lecture as I told you last class so the seismic instruments are used to record seismic waves okay. So we have seen that single component seismic instrument where the vertical component of the earthquake will be recorded. So 3 component 1 vertical and 2 horizontal component of the earthquake is recorded okay. So these earthquakes are recorded in the seismic station.

Then how this earthquakes are quantified okay how this earthquakes are scaled okay so the low earthquake, big earthquake, high earthquake how it is quantified.

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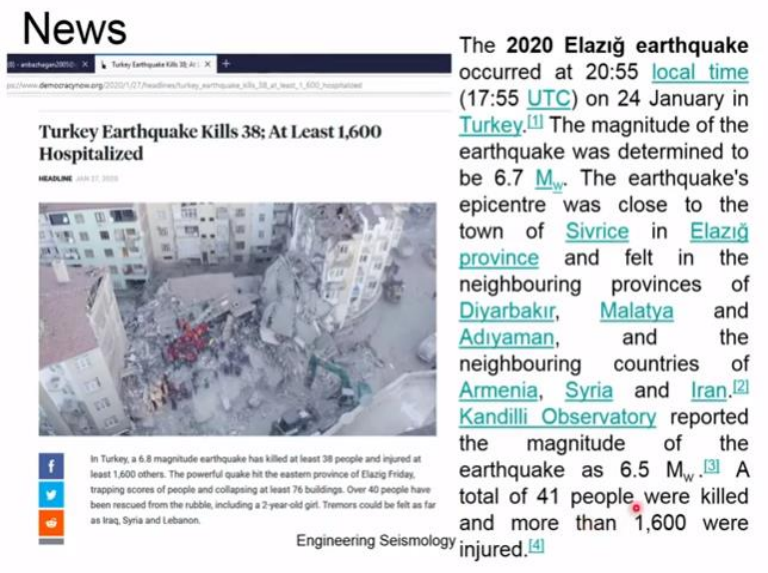

So let us see some of the earthquake reports okay is been reported this is some of the Turkey earthquakes so it killed around 38 people at least 1600 people are hospitalized. You can see that the magnitude of 6.8 is actually mentioned okay magnitude of 6.8 you remember they have written magnitude 6.8 okay. So then parallelly for the same earthquake okay the same earthquake there was a another news so which is written that so Elazig earthquake occurred on so and so time and the local time on twenty fourth January Turkey.

And the mean the magnitude of the earthquake was determined to be 6.7 Mw okay so here it is written 6.8 magnitude it is written 6.7 Mw then so many people died and all those things okay it is written and then they also said that the neighboring countries of Syria, Iran observatory the magnitude of earthquake as 6.5 a total of 41 people died so something is written okay.

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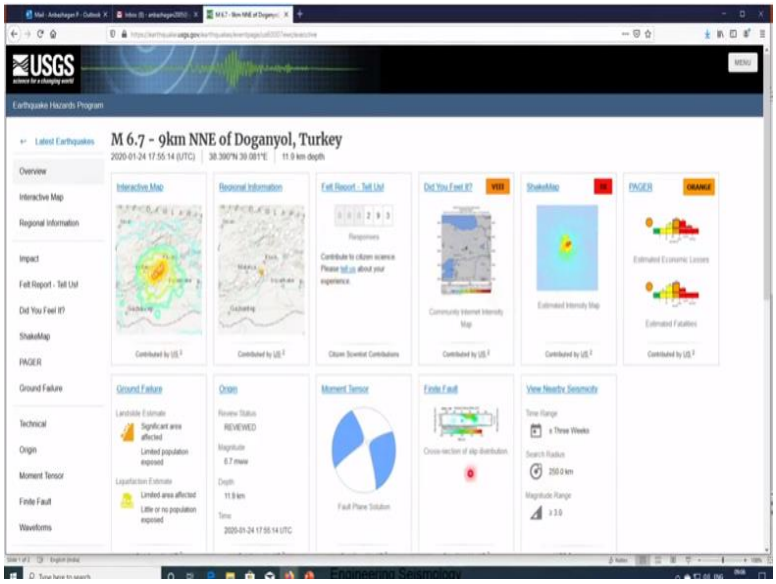

So similarly if you see the another earthquake is so may be the same earthquake where you can see there was a map which is published with there have some lines okay you can see this are all the some lines and the maps are published. So then they also given the location of the earthquake then I was telling you the shake map okay where IMD also releases it is given. And also they release a warning system okay the pager warning system so about this earthquake with respect to economic loss and fatality loss this is.

So this is the generally the each earthquake report being released and reported that earthquake information like the fault mechanism and then how many people felt and what was this isoseismal map and then what was the acceleration time history and all.

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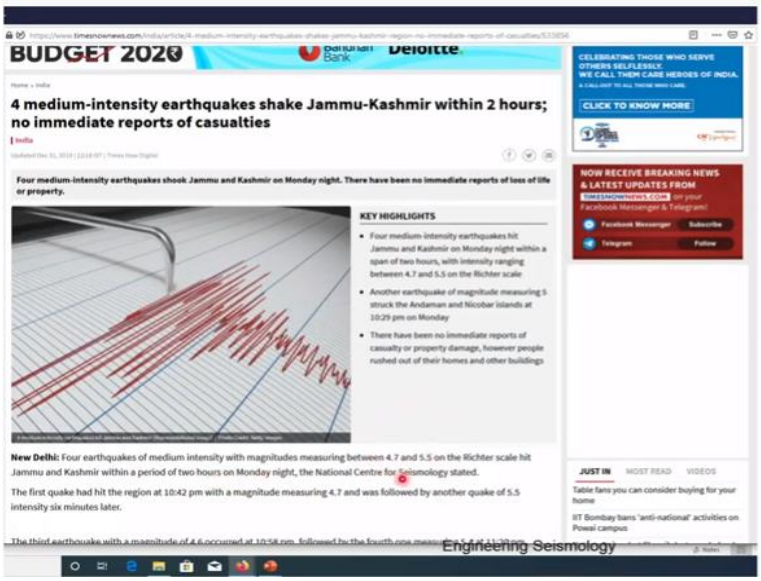

So this is another earthquake where it is I think it is reported in India, Indian earthquake. So basically this earthquake occurred in Jammu and Kashmir they reported that 4 medium intensity earthquake okay shake Jammu and Kashmir within 2 hours no immediate report of casualties okay. So then the report the 4 earthquake of medium intensity with magnitude measuring between, 4.7 to 5.5 in the Richter scale hit Jammu and Kashmir okay. So that is what the report it released.

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So similarly there is a scientific report on the earthquake kind of things you can see here this is about the Bhuj 2001 earthquake. So they have written that so the India was celebrating as a fifty first republic day on earthquake of 6.9, intensity on Richter scale. So you should note that 6.9

intensity on the Richter scale epicenter. So if you glimp I mean try to see all the 4 report so somebody reported magnitude, somebody reported moment magnitude, somebody reported intensity, somebody reported Richter scale okay somebody registered magnitude on Richter scale.

Somebody reported intensity on Richter scale so what is this? Okay it is really like a magnitude is the quantifying scale or intensity is the quantifying scale. There was a confusion so the magnitude basically literally if you show by go by the meaning so the magnitude is basically is something which is measured as a magnitude. So intensity is something which is intense like the felt effect kind of things intensity this is a literal meaning.

So this people giving a; some kind of mixed kind of observation on that so in order to understand and study the earthquake well. You should know how to quantify a earthquake okay how to earthquake can be quantified okay. The concept of earthquake quantification so, that is what we are going to discuss today class. So after this, class we will be understand what is the earthquake you should report with scale you should measure which way you can report a earthquake to the general public who does not have the any knowledge okay.

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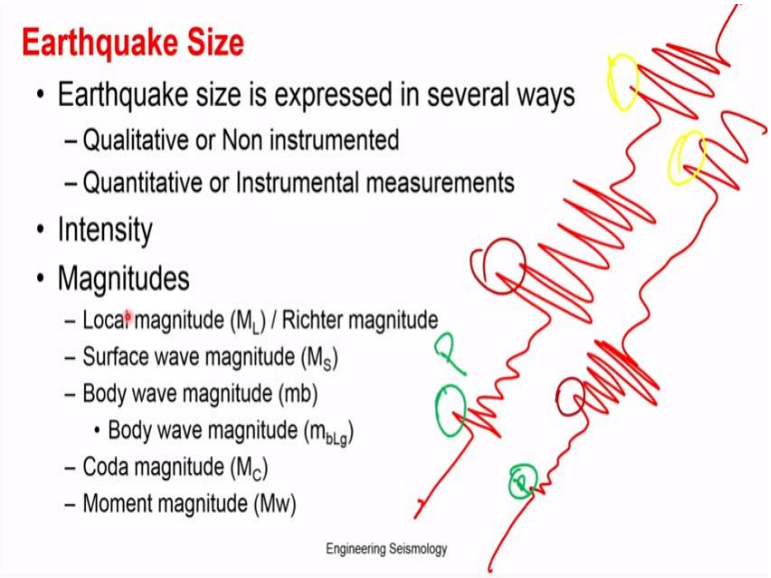

So the earthquake size okay can be expressed in so several way the most suitable way is actually one is that qualitative wave the another one is actually the quantitative or instrumental way. So the quantitative way is basically non instrumental way of representing the earthquake size that is

the qualitative way. So this practice being used before installing the instrumentation to measure earthquake that is the qualitative way.

So the quantitative way is after installing the seismic instrument at particular place whatever record we are getting that data is used to quantify a earthquake that is the quantitative way or instrumental measure of earthquake. So there are 2 way we will report this one, one is that intensity and magnitude. So the intensity magnitudes are not equal intensities are the some quantity qualifying the earthquake size or quantifying the earthquake size in qualitative manner.

Qualitative manner means like approximately defining okay based on the some qualitative observation is the intensity value. The magnitude is basically the measure what instrument does what instrument does? Basically the seismic instrument we have seen that it measures a seismic wave. So how it measures basically it measures so like this you can measure so depends upon the place okay so where it is there.

So it will be measuring the signal correct so like this so as we have seen that okay so this basically. So as we have seen that this basically a arrival of P wave this is the arrival of P wave okay. So similarly we can also see the arrival of so S wave the arrival of S wave similarly we can also see there the arrival of other waves surface wave. So depends upon the location of the instrument you can get a particular wave type in your place.

So based on this wave type okay you can estimate a size of earthquake that is quantitatively you can estimate based on this record that is called as a magnitude okay. That is the magnitude of the earthquake where you can sell a size. So what are those magnitude depends upon the what type of wave you use the magnitude scale will be different type. So one is that is basically a Richter magnitude or a local magnitude you can see that the Richter magnitude local magnitude which basically developed by the Richter we will discuss in detail (()) (08:57).

Then another one is the surface wave magnitude so you can see that this is the magnitude which used from the surface wave. The body wave magnitude where the body wave is used here the Coda wave magnitude where the Coda wave is used the later one was the moment magnitude this is the most advanced version of estimating the quantifying the earthquake using. So the wave; form data from different station without error.

So in this class we are going to discuss in detail intensity and magnitude it is development okay so why because as we have seen that until 1960 India does not have many seismic station. Even today the number of station available are very less because of that the intensity scale also practice at several earthquakes are reported in the form of intensity, so that if you know the intensity value you know the severity of the earthquake that also used for estimating the hazard and other things.

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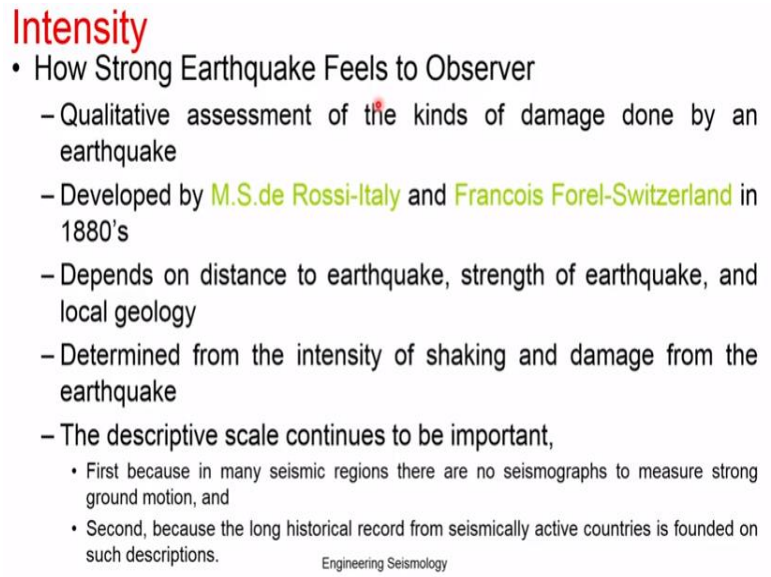

So what is mean by intensity so the intensity basically tells how the strong earthquake feels or to the observer. So that means the intensity scales are basically made and designed such that a person in the particular location based on his level of perception of the seismic wave. The intensities are scale okay for the lower level the higher level this also scales okay the qualitative assessment of the kind of damage done by a earthquake okay.

How the earthquake caused damage so this was developed by the basically the M.S.de Rossi-Italy okay. Then the Francis Forel- Switzerland so they joined together and developed this intensity scale in eighteen eighties where there was a research started for the seismic instrumentation. So depends upon the distance of the earthquake strength of the earthquake and local geology the damage changes.

So that has been notified and observed and that used to size a earthquake so depending upon the earthquake strength okay the local geology this intensity scale various determined from the intensity of shaking and damage from the earthquake. So this is actually the disruptive scale continuous to be important because many seismic regions that is no seismic seismogram to measure strong ground motion okay.

Second the long historical record of seismically active countries found on the only such descriptive scales okay. Where remaining old earthquake as; I said that there is no recorded data because there is no seismic station. Even India there are many earthquakes we can say like that because of that the intensity scales are very important and being continuously used. So what are the different types of intensity scale as on people practice.

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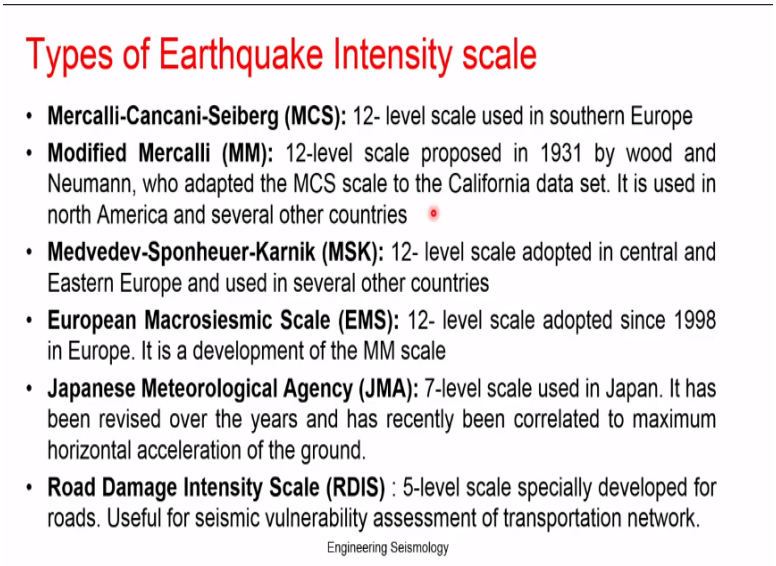

So, one is that a Mercalli okay Cancani-Seiberg scale which is a 12 level used in the southern Europe. Then the modified Mercalli so which is like a 12 level scale proposed in 1931 by wood and Neumann who adopted MCS scale to the California data set. It is used North America and several other countries. The another one is like a Medvedev so MSK scale basically the 12 scale adopt central and Eastern Europe used in the several other countries.

The European Microsiesmic Scale EMS 12 level scale adopted since 1998 in Europe it is development of the MMI scale okay. So the Japanese Meteorological scale it has a 7 level used in Japan it has been revised over a year and had recently been correlated with the maximum

horizontal acceleration on the ground. So the road damage density scale it as a 5 level scale specially developed for the roads useful for seismic vulnerability assessment of the transportation network okay.

So we are going to discuss this intensity scale in detail so if you see overall actually the first 4 scale as a 12 level only depends upon the where it has been used it has been renamed when they use southern Europe it is MSC when it used in the north America and several other country is MM then used in the Eastern Europe and several other committee MSK and European it is completely it is a EMS.

But overall the scale 12 level is remains same so another level Japan which has a 5 level scale only used in Japan. The RDS is the recent scale which has a 5 level Japan as a 7 level scale okay is the 5 level. So we will discuss each one in detail.

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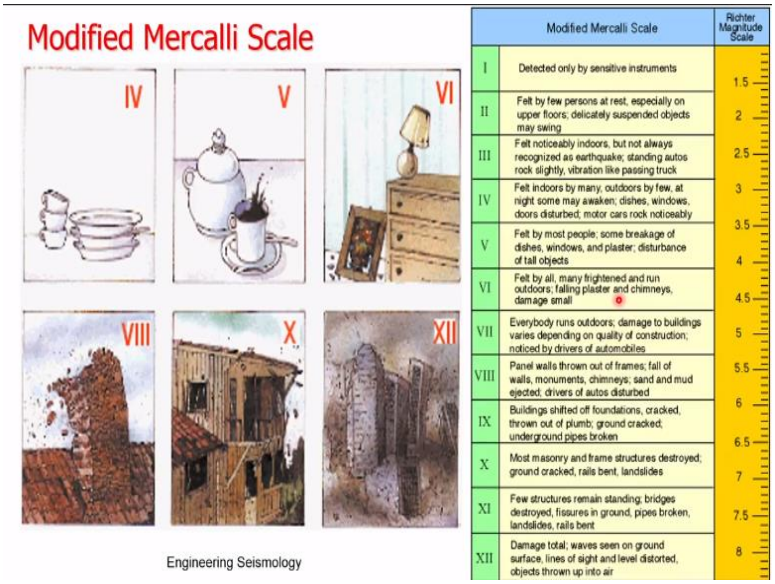

So overall the 12 level okay so the most widely it is called as a modified Mercalli intensity scale or MM scale or MMI scale. So this as 12 level of describing the earthquake felt observation or earthquake damages. So what they do those days they will train some person okay then based on that person perception we will tell that what is the intensity of the earthquake if there is no damage?

You can see that the level detected only by the sensitive instrument so when there is no seismic instrument. So generally the level 1 never been reported it is not at all there but since you cannot start with 4 or 5 as a scale. So the level 1 as to be there level 2 felt by the few person at rest especially upper floor okay. So delicately suspended object may swing there is the level 2. Level 3 felt noticeably indoor but not always a recognized as a earthquake standing autos rocks slightly vibration like passing a struck that is a level 3.

Level 4 where felt indoor by many outdoor by few and might some may awaken dishes windows and door disturbed motor car rocks noticeably. So this is the where the human can feel if the felt all the people in particular area felt a vibration that will be the intensity 4 and 3. Before that they cannot feel okay so they felt most people okay some breakage of the dishes windows and plaster and disturbance or tall object where you can start noticing the building damages, building damage on 5 onwards.

So that means somewhere it is intensity 5 is reported in the history there may be a damage of the building has been noticed doing that earthquake. So 6 felt by all many frighten and run outdoor so falling of plasters so chimney is damaged all those things are 6.7 everybody runs outdoor damaged buildings where is depending upon the quality of the construction noticed by the drivers and automobiles.

So 8 panel walls throw out of the frame so false wall window, monuments, chimney stand mud ejected drivers so this are all the some of the ground deformations also occurred in the 8. So 9 the building ship or foundation cracks and have a greater damage okay so where underground pipes broken. So 10 most masonry frame structure destroy ground crack rails bend landslide. You can see that the landslide and railway network come into the location of basically scale 10.

11 few structure remain standing bridges destroy fissures like bridge, pipes broken, landslide, rails bend. So 12; damage total waves seen ground surface lines slightly level destroyed of object thrown up. So you can see that the description what they observed in the several earthquake has been put together to frame this intensities scale okay. So that is what it says sometime you say specially get this kind of definition; you may not get for example.

So India most of the places we have the predominantly mud structure okay in the same city you can also see a RCC structure reinforce cement concrete and planes cement concrete structure. If these 3 structures are behaved differently, so which scale you should use should be you should have the knowledge you cannot try all together same place the magnitude 6, 7, 8 that is a wrong okay that you should know.

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I. Instrumental	Generally not felt by people unless in favorable conditions.
II. Weak	Felt only by a few people at best, especially on the upper floors of buildings. Delicately suspended objects may swing.
III. Slight	Felt quite noticeably by people indoors, especially on the upper floors of buildings. Many do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration similar to the passing of a truck. Duration estimated.
IV. Moderate	Felt indoors by many people, outdoors by few people during the day. At night, some awaken. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rock noticeably. Dishes and windows rattle alarmingly.
V. Rather Strong	Felt outside by most, may not be felt by some outside in non-favorable conditions. Dishes and windows may break and large bells will ring. Vibrations like large train passing close to house.
VI. Strong	Felt by all; many frightened and run outdoors, walk unsteadily. Windows, dishes, glassware broken; books fall off shelves; some heavy furniture moved or overturned; a few instances of fallen plaster. Damage slight.
VII. Very Strong	Difficult to stand; furniture broken; damage negligible in building of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken. Noticed by people driving motor cars.
VIII. Destructive	Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture moved.
IX. Violent	General panic; damage considerable in specially designed structures, well designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X. Intense	Some well built wooden structures destroyed; most masonry and frame structures destroyed with foundation. Rails bent.
XI. Extreme	Few, if any masonry structures remain standing. Bridges destroyed. Rails bent greatly.
XII. Cataclysmic	Total destruction - Everything is destroyed. Lines of sight and level distorted. Objects thrown into the air. The ground moves in waves or ripples. Large amounts of rock move position. Landscape altered, or leveled by several meters. In some cases, even the routes of rivers are changed.

So this scale okay so for the mapping purpose this scale also used in the color gradient you can see the color gradient. So the, light blue okay so the light green, yellow and red light red, dark red and then very dark so reddish black so where you can see the extreme 12. So by using the color coding one can able to see what magnitude what intensity has been expected in this region? So if you go back to the first slide okay here you can see the color coding.

Now you can understand why the isoseismal maps are color coded on different level so by seeing this you will understand how the damage is severe at a particular location. So, now as on this class going on you maybe seeing that each day okay, so they release a COVID-19 ward update map. So the map basically red, orange and green okay so the red means there is a active case, orange means it is basically active case passed the first quarantine period.

Then okay green means there is no active quarantine cases so this also they use 3 grading system most of the state and then the city level they release this kind of map every day for the make a

mobility easy planning and all those things. So similar way these kind of color coding map help easily to understand how the earthquake is caused damage.

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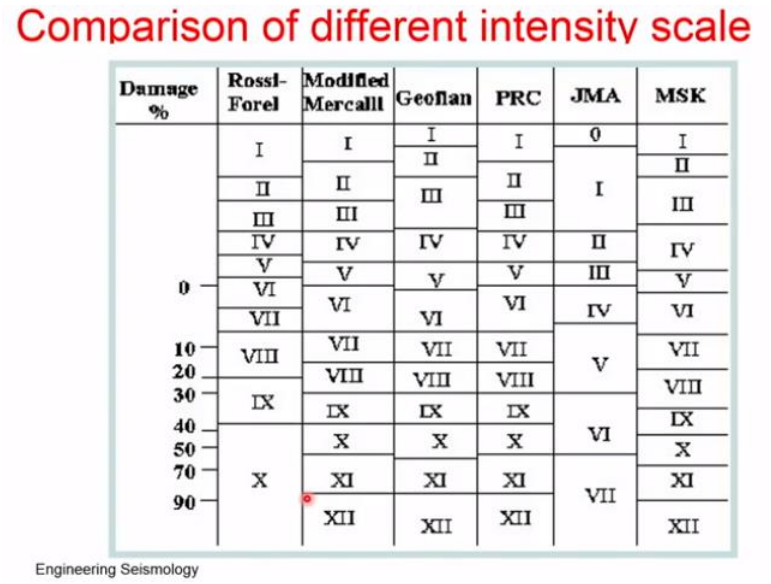

So you look at all this scale basically so you can see the damage level expected in the building and then a different scale. So even though there are scale which is 12 in nature but this 12 you can see more or less this goes up to 4 there is a slight difference is there after 4 it almost same okay. Then the MSK scale you can see say Japan scale and then Rossi-Forel scale there is a difference.

So more or less anything which reports the building beyond 50% so it will be called as a intensity 10 and above in the 12 scale and but it is 6 and above in the Japanese scale of 7 okay that is a comparison you can get from this figure.

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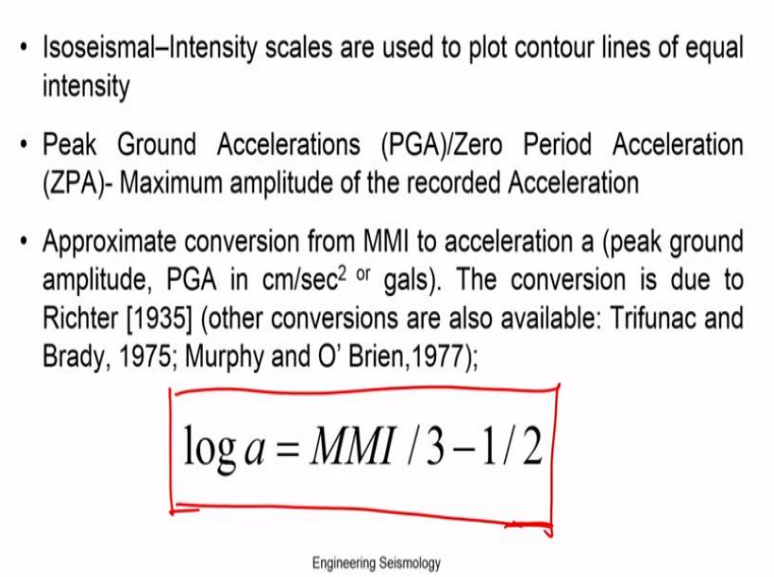

So this intensity scale okay so use to plot a equal intensity okay so then join a equal intensity through a line that line is called as a isoseismal line okay. So now a days this intensity scales are basically we used to so this intensity scales are basically used to convert to magnitude there are some equations people have developed based on the so their regional data and then they given. So where we have even the old MMI values which you can use to convert to the acceleration for the design purpose and engineering analysis okay.

So this acceleration basically peak ground acceleration are 0 period acceleration maximum amplitude of the recorded acceleration which we will discuss in the interpretation data time what is the peak ground acceleration and 0 period acceleration or maximum amplitude recorded acceleration in detail. But now we should know that there is a conversion between the engineering quantities or quantified way of earthquake measurement of acceleration to the intensity using these relations.

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TABLE 4.2 Comparison of Modified Mercalli (MMI) and Other Intensity Scales

a gals	MMI Modified Mercalli	R–F Rossi–Forel	MSK Medvedev–Sponheur–Karnik	JMA Japan Meteorological Agency
0.7	I	I	I	0
1.5	II	I–II	II	I
3	III	III	III	II
7	IV	IV–V	IV	II–III
15	V	V–VI	V	III
32	VI	VI–VII	VI	IV
68	VII	VIII–	VII	IV–V
147	VIII	VIII+ to IX–	VIII	V
316	IX	IX+	IX	V–VI
681	X	X	X	VI
(1468)*	XI	—	XI	VII
(3162)*	XII	—	XII	

* Note: *a* values provided for reference only. MMI > X are due more to geologic effects.

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So this is the basically the acceleration in gals okay with respective intensity scale. You can see how the intensity scale so this was basically reported by the different earthquake recordings and then there was a some kind of a normalized table has been derived for this.

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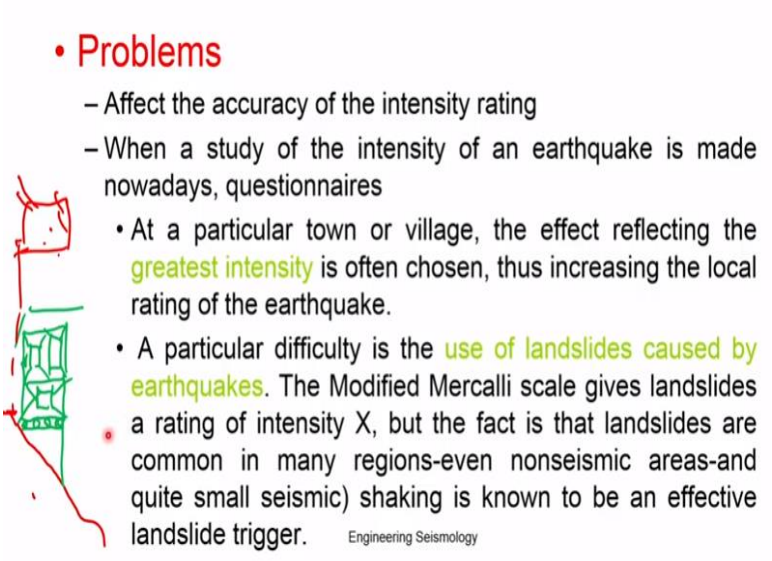

So this intensity scale okay basically affect the accuracy of the intensity rating. As I told you that they train a people ask them to tell the intensity value sometime as you know that among the people itself there are people who are very sensitive to the sound and vibration there are people they are not even sensitive to the any kind of vibration signal. So depends upon the person to person this intensity scale may vary it is not straight forward the same at different phase because of the perception of the people and the sensitivity of the people.

When the study of intensity earthquake as made now a days is questionnaires is that at particular town or village that they affect reflect in the greatest intensity often chosen those increase in the local rating of the earthquake. A particular difficult you use landslide caused by the earthquake. The modified Mercalli intensity gives landslides rating up 10 but the fact with landslide are common many region even non seismic areas okay where the landslide may taking place.

Because the landslide sometime occur due to the rain okay so due to the rain the slope is saturated and become a less shear strength slope when there was a vehicle goes small that vibration causes a landslide. But the intensity 10 says it is very highest level so such kind of ambiguities are always are occur and moreover this intensity. For example I told you that in the same place you have the mud building RCC building and then the normal brick wall construction houses in the given urban area.

All of them are located within the same line it is very common in India the mud building completely collapses other 2 buildings as a crack. What intensity scale you will assign that depends upon the person who, survey the house okay. He will preferably give the highest range but it may not be right okay. Sometime so there was a experience which I gained during my visit to Sikkim. So where there was a traditional construction house okay the traditional construction house how they constructed the house basically.

In Sikkim hilly area they follow their own tradition way of bringing so the basically the hills are having slope like this okay. So, how they constructed the house in the traditional way so they made like the wooden frame like this. So then they made a wooden frame so in this they put a wooden roller kind of wooden rod tree only chopped the branches then again they made a wooden frame and again they build a house with 2 floor okay.

Then they had a window that window was base so this all completely wood like this so it completely wood with the frame and door openings and all. Then followed by this are wooden panel plasted with mud with Cow dung or a cement paste okay. So in the same place basically so this was the road so in the plan this road was basically extending like this there was a another place where the RCC framed structures are constructed which was basically some Christian Church in the same area which was not very far about a 100 meter distance.

So when we went to do the observatory survey soon after the some earthquake basically this house have not even a minor crack but this, particular house completely add a damage. So now which one you will take into consideration making the intensity scale. So even though this is according to engineering point of you which is not a pukka engineering structure but it is concrete to be believed RCC building to be believed to be engineering structure.

But it as a damage it does not have damage so this kind of complicated situation will arise okay where the judgment person would doing the survey will take a roll to decide what is the intensity scale that was the one big problem in the intensity scale okay. Actually this is the traditional practice even though it is not non-engineering structure this is the traditional practice even though it is a non-engineering structure. But since people there you see they know the earthquakes are occurring in that region.

They used this wooden as a base connecting 2 floor one with the connected with the rock another is house. So this when earthquakes are occurring basically this rolls here and there so which is basically makes house intact not creating any damage. So this is the traditional practice where northeast people are using but nowadays because of this concrete jungle or concrete knowledge to the many people knowingly unknowingly believe that concrete houses are also stronger.

But it is not so on okay concrete maybe you give aesthetically a good appearance and view but this kind of scenario where the concrete house actually collapsed completely but this was intact. Okay if the concrete house not designed as per engineering design requirement it is disaster's okay. But the traditional house even though it may not, be the scientifically having the equation or with the design parameters. But since is the traditional practice is survived the earthquake.

So this kind of issues will come in your assigning intensity scale damage level based on the building there was a another situation where the earthquakes are occurring in the forest okay. There was a many place you; know that there was a forest they earthquakes are origin in that place it propagates. In the forest no man will be living and no house will be there so then how do you people know that this way earthquake has happened or not.

If the forest is having like a 200 kilometer radius forest is there so you may not even feel the earthquake. But that earthquake maybe very stronger okay been since there is no people there is no report it does not mean that there is no earthquake. So that is what happened when we have the poor seismic instrumentation since historic time you might have missed many earthquake which is happened in the remote area like sea as well as in the forest or non-habitat places.

So that is where you may not notice and recorded that values as earthquake but that might have happen that seismic estimate continue in that region okay. So that was the issue.

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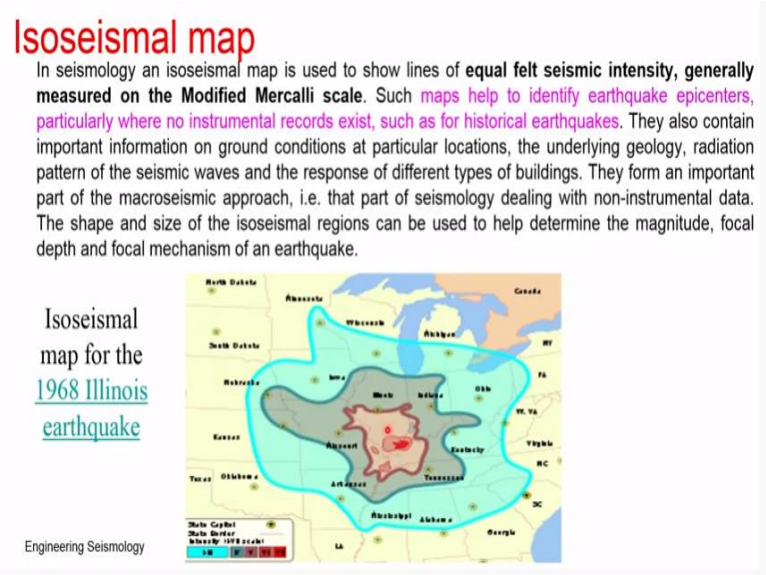

So as I tell you that isoseismal line so the isoseismal line is basically the equal intensity connected grid line. Okay line which, connect a equal intensity is the isoseismal line. The map which is showing a several isoseismal line is called as a isoseismal map in seismology map is used to plot a equal felt intensity and generally measured modified intensity and then there give a color coding depends upon the intensity level which will help you to identify where was the origin of the earthquake.

Basically the higher and concentrated places like this will be the historic okay so location of the epicenter of the earthquake based on that only they define this is the epicenter of the earthquake okay. Based on the known knowledge so, this is the typical isoseismal map okay for the 1968 Illinois earthquake.

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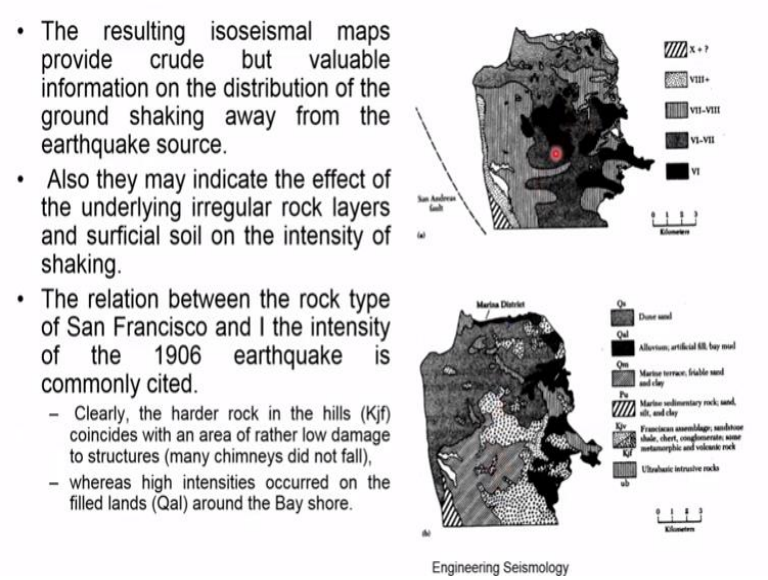

So this isoseismal map people found that the isoseismal map reported in the area and well match with the geological data of the region. This is basically a San Francisco intensity map you can see the San Francisco intensity map San Francisco geology map you can see there is a similarities which you can understand much better in the color scale.

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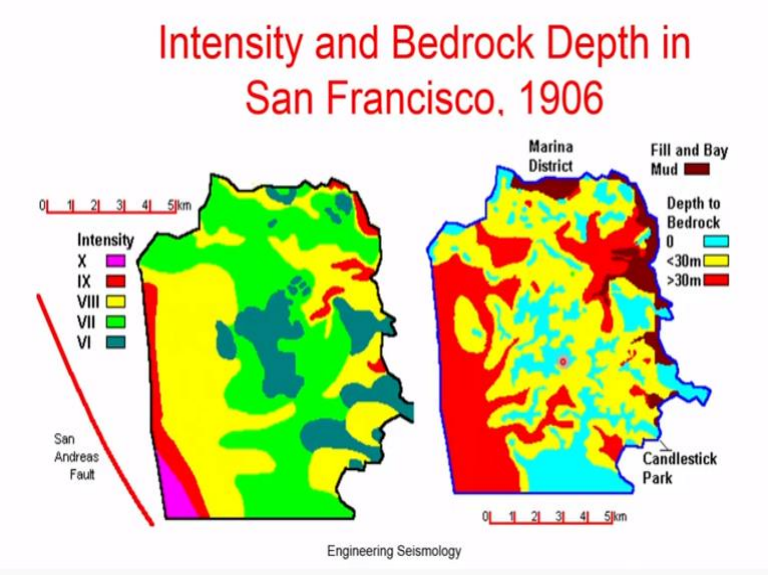

This is the fall when earthquake occurred this is the, this one this is the thickness of the soil like rock okay bed rock and then soil thickness. You can see that so wherever there was a high intensity okay there was a deep soil found in that region. Wherever there was a low intensity like this black spot you can see a less bed rock or surface rock region where the damages or less. So provided your buildings in this area; throughout the regions are similar.

So you can also understand the role of geology and soil in the region using this kind of studies. So this was the origin where the earthquake geotechnical engineering started people try to understand how the earthquake, okay so influence by the soil in that region. The earthquake damage is responsible from the soil deposit in the region because of this kind of observatory data's comparing with the geology and intensity of this earthquakes.

So this is about the intensity scale standard way where the building damage and then the report of the earthquake, has been being reported. So these are all about the, we said that there was a 4 type of intensity scale all of them have 12 level there is a Japan intensity scale 7 level. Since the 12 level is most widely used we have discussing about the 12 level we also talk about the isoseismal value isoseismal map problem with the intensity scale okay.

So, how they intensity scales are helping to identify the geology the region if the buildings are similar, okay. The next class we are going to discuss about the road damage intensity scale okay which will be so developed by; myself okay. So I will tell you why I developed in the next class so with this class we will thank you we will meet in the next class thank you.