Introduction to Engineering Seismology
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Module No # 03
Lecture No # 13
Seismic Instrumentation in India

So vanakkam so we will continue our lecture on Seismic instrumentation. So far we discussed about the earthquakes ok. So what is the seismic hazard and different types of seismic hazard we have seen. So then we also try to understand how the seismic events are occurring where the earthquakes are occurring so plate tectonics. So we also studied about the different types of earthquakes with respective to the energy released where it occurs, depth ok.

Then followed by we also studied about the earthquake instrumentation like how to record a earthquake ok. So how to measure which what is the seismometer, seismoscope how it works ok. We also discussed about the oldest seismic instrumentation of Chinese seismoscope also we discussed. So we studied that the different type of seismic instrument with respect to the period ok and then the data it record. We also see in the seismogram accelerogram.

So the accelerogram is basically instrument which records acceleration is the accelerograph ok. So where you can get a acceleration versus time. So general earthquake so mostly it is recorded as a velocity versus time which is called as a seismogram ok. So the instrument which records is seismogram. So this is the development we have seen in the first seismic instrumentation was basically 1880 that is the first time where the seismic instrument has been released or invented in world.

So even that there was a Chinese seismoscope, but which was officially recording the any data. It only gives you the direction of the earthquake. So as I told you in the last class you can Google it and find out how the seismoscope works because there was a detailed x-ray based study where the oldest seismoscope their basically took x-ray and try to understand what mechanism it has been used which was not breakthrough until 2018 ok.

So up to 2018 people are suspicious how it works but after 2018 so they find out using the modern technology without breaking the equipment how the seismoscopes are working what is the principle behind that they also explained that. So those who are interested to work on the seismic instrumentation or know about the seismic instrumentation building or developing the new seismoscope so they can read those kind of things which will help you basically to come up with the new seismic instrument.

So as I told you that India as on now nobody produces the seismic instruments to measure the earthquake. So we all basically import a several seismic instrument; from abroad and it has been used. So we also, seen that this seismic instrument located place is called as a seismic station ok. So we have also seen what are the minimum requirement; for the locating seismic instrument at particular place.

So it should be free from any kind of cultural noise. It should not be located on the soft ground sites which is not suitable. So then we have seen that there are 3 way people maintaining the seismic network. So global network, national network and seismic array okay, so we studied that the global network is basically it is the instrument which very broadband in nature can able to record any earthquake occurring anywhere in the world. So it is very sensitive equipment generally the each county at least 1 or 2 global network should be placed.

So we also understand that this global network not only record the earthquake anywhere in the world it also record a nuclear testing or any blasting in and around the world particularly the developed countries basically sponsored this kind of network to the developing countries and try to see what kind of activity is going on with respect to the nuclear testing or development. So we have also seen in that this helped basically to detect even the Pokhran atomic testing by the Doctor Abdul Kalam in Rajasthan ok.

So these the instrument because of the seismic instrumentation global network only they could able to identify there is a blasting happened so and this was the energy released by this. So based on that they have come to know that this is the biggest energy released by the nuclear explosion energy released by the, another explosion will be completely different. And area they felt and all

those things will be completely different. So this data they used basically to know that we have tested atomic testing missile facilities kind of thing.

So after basically the global network the next one is actually the region network. So, generally regional network has to be done for each region. So that you will know what is the depth of the earthquake and as well as what is the magnitude it is and then what are the active seismic sources which will help to seismic hazard analysis. Which we are going to discuss later stage so the regional networks are very important to get a reliable prediction of earthquake hazard.

How much magnitude going to happen how if that, magnitude happen how much the PGA you expect the regional network is available you can predict very precisely. Moreover whenever you want to place a important structure you need to know which are the places are seismically active, which are the places are non-seismically active. Those, kind of information can be obtain from the regional network so the, another one is actually the array.

So array is actually the number of station so which is not similar to regional but it is very small scale where they tried to understand how the wave propagation changes at a smaller scale ok. So for example if there is valley, bridges ok in the region with the different soil thickness how the seismic wave changes from one point to other point which has to be studied and for the research point of view this arrays place a very important role to understand how the seismic propagation taking place.

How the amplifications are taking place? Those are the details we can get from the seismic array. So we also seen, that there is a minimum number of station record for a particular place. For example any azimuth should be in between the station should be less than 180 degree and then if the area and the spacing, the spacing should be twice less than the twice of the depth of the earthquake in the region. So we have seen that what is the minimum requirement spacing; for this one that you should remember.

So that is a scenario where internationally people build or arrange or develop a seismic network. So that using that data one can predict a earthquake hazard possible feature earthquake forces so that you can design your structures on that. So let us see what is our country; status on seismic instrumentation ok.

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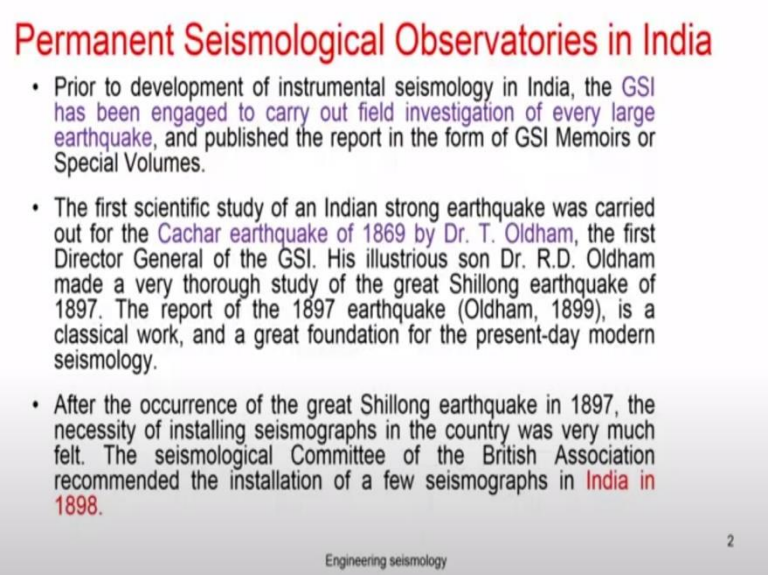

So if you look at India so there was lot of past earthquake damages reported in the literature ok. As I told that there was so city called Poompuhar even it is washed away by Tsunami ok. It was maybe around 800 years back. So like that there are many cases where the historic events are reported in our olden literature. So even the palm leaf literature it has been written. But as per Indian seismic instrumentation concern which was not very old as our earthquake history ok.

So if you look at the earth quake study itself the modern kind of study or with people details understanding of the seismic hazard is started just about maybe 120, 30 years back not that beyond. So; with the prior to the instrument seismic instrument development in the country ok. So the generally the GSI which is part of the British government system so used to engage to carry out the investigation of the soon after any large earthquake in the country during that period.

So it was the oldest information we have in terms of the earthquake damage report and then quantifying the earthquake ok. The quantification of the earthquake will be discussing in the next class but to quantifying the earthquake. So this was basically GSI geological survey of India controlled by the British government is involved and during the field investigation in the large earthquake. Soon after earth quake the member of the GSI group will go there and do the sight observations and report what are the damages are reported in the area.

Based on that they can guess that what was the level of magnitude or level of earthquake it is. The first scientific study of the Indian strong earthquake was carried out so the for the Cachar earthquake in 1869 ok so the Cachar earthquake 1869 by Doctor T. Oldham. So he was the first direction general of GSI. So his illustrious son of Doctor R. D. Oldham made a very through study of the great Shillong earthquake of the 1867.

So the first report was observed on the Cachar earthquake in 1869 then followed by there was a 1897 there was a big earthquake which is occurred in the Shillong region which was studied by the Doctor R. D. Oldham ok. So he was the basically this Oldham both are from the same family. The report of the 1897 earthquake ok the Oldham it is published as a 1899 report is a classical work and a great foundation for the present day modern seismology in India.

So that was the first earthquake where this study has been done in detail and people try to understand how the earthquake causes different seismic hazard parameters ok. Difference seismic hazard like such as what we discussed was direction ground motion, direct deformation, amplification, liquefaction, land slide. So these are all, the hazard how it reported in the Shillong earthquake has been well described in the Oldham 1899 publication which was carried out by the R.D. Oldham in as soon after the 1897 earthquake.

So after occurrence of this great earthquake, ok so in 1899 the necessity of installing seismogram in the country was very much felt by the British government then the seismology committee of the British association recommended insulation of few seismogram in India in 1898 ok. The Shillong earthquake is basically the origin of the today seismic instrumentation in the country.

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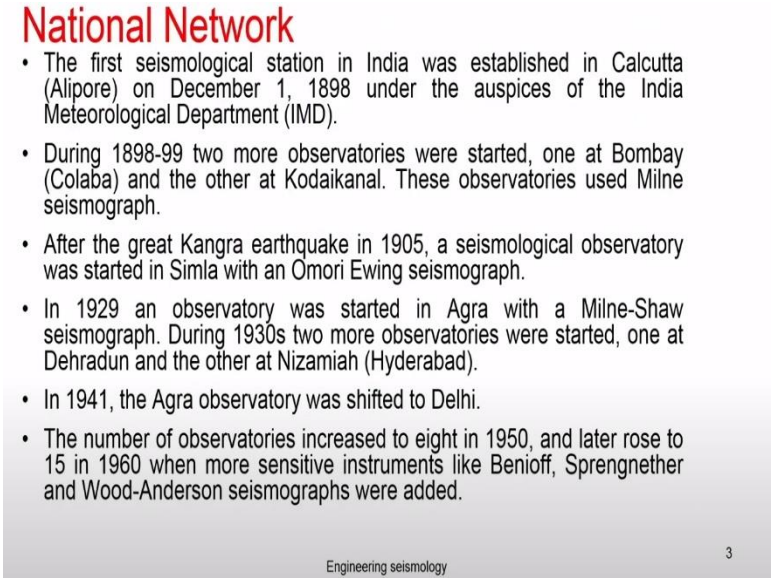

The first seismological station in India was established in Calcutta the place called Alipore. On, December 1 in 1898 under auspices of India Meteorological department where the IMD was created ok in 1989 where they first deployed seismic station at Calcutta. Why those days actually the Calcutta, Chennai and Mumbai are the big port where lot of materials has been exported to the British government. So this place they used to feel that this is very important place to know the earthquake is. So that was the Alipore region.

So during 98 to 99 ok in the short period of 1 year the 2 more observatory started one at Bombay and the, another at Kodaikanal. So you may be worried that so what is the relation between getting the Bombay and Kodaikanal? So if you see that the Calcutta was port, Bombay was the port then why the Kodaikanal? So those days actually the British people because as we know that the summer is very hot season. So they used to go to take rest at the Kodaikanal ok.

So those place they so because of that hilly region so they felt that some station can be kept there so that when ever they go there they can also have guest house kind of thing. So these observations are used by the Milne seismogram which was developed in 1890 by the scientist Milne which you have seen at the last class at. So after the great Kangra earthquake in 1905 the seismological observatory was started in Simla with an Omori Ewing Seismogram.

This was another type of seismograph which was there in those days but those instruments I am not very sure now it is available. So you can see that so up to 1900 so we have roughly about ok

so 5 seismic stations in the country. That means from now 120 years back we had only 5 seismic instruments in India and this instruments also kept so very far each other.

So why you need to have this knowledge so when you see some kind of seismic record, by mistake those people written that this earthquake was record on 1850. You should know that this earthquake is recorded or not if you know the history of seismic instrumentation in India that is the reason. So in 1929 the observatory was started in Agra ok with Milne Shaw seismogram. During 1930 2 more observatories were started. 1 at Dehradun and the, another at Hyderabad so, those days it is called as Nizamiah so in Hyderabad.

So you can see that in 1930 so we had about 7, seismic instrumentation in the country. In south side there was 1 at Mumbai and there was 1 at Kodaikanal and 1 at Hyderabad, so in north Dehradun, Shimla and Calcutta so these are all the north station. In 1941 the Agra observatory was shifted to Delhi ok. So even though it has been installed in 1929 in the Agra it has been shifted to Delhi in 1941. The number of observatories increased 8 from 8 to 15 ok.

So increased to 8 in 1950 later to the 15 to 1960 that means up to independence we are having only 7 equipments ok. Then in 1950 there was a one more equipment is added then it become a 8 after the independence. So after the independence then we ordered 5 more seismic instrument. 1960 it become a 7 more we added basically. So it become a basically 15 seismic instrument in India such a big country we have the 15 instrument in up to 1960 ok which is about 60 years back ok.

Where the world was almost attained a modern seismic instrument during the 1960. And more sensitive instruments like Benioff then the Sprengnether and Wood Anderson seismogram was added in the later stage ok. So that was the seismic instrumentation history. So that means up to 1960 ok so we have only 15 seismic instruments. So among that there was about 4 seismic instrument in southern India. So remaining were in North India where there was a frequent small earthquake has been reported ok.

So that was the status you can know that how the data before sixties are accurate how it is reliable. As you know that the number of instrument and spacing between the seismometers are very important to precisely predict a epicentral distance and depth of the earthquake. That is

what we have seen in the wave propagation. If you have the insufficient instrumentation basically you will end up in the predicting the large error in the epicentral as well as the depth of earthquake ok.

So as you know that using 1 seismic instrument you cannot predict a epicenter location. You can only predict a radial distance of the epicenter that is all. So that means if any earthquake occurring at close to one seismic session may recorded that but because of insufficient seismic stations the location predicted by this instruments are having the error. That you have to have the knowledge because this is help in the hazard analysis interpreting the earthquake data; what you have. You cannot blindly take some data and believe that that is 100% correct.

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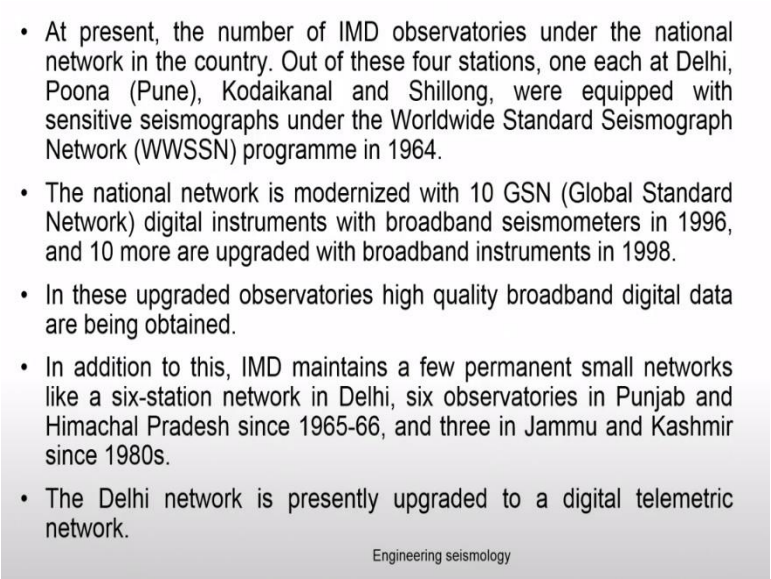

So at present basically the IMD is the nodel agencies okay where the entire country network has been maintained by them. Out of the 4 station 1 at Delhi, 1 at Pune, 1 at Kodaikanal, 1 at Shillong were equipped with sensitive seismogram under the worldwide standard seismogram network WWSSN which we have seen during the last time. So this is like a very broadband kind of things during the program of 1961. So you can see that so the developed countries want to spy us so they have put the world global seismic station at India during 1964.

The national network is modernized okay with 10 GS global standard network digital instruments with broadband seismogram in 1996 and 10 more upgraded with the broadbands instruments in 1998. You can see that up to 2000 ok we have almost close to 35 equipment's ok.

So 35, seismometer in the whole country so this upgraded observation high quality broadband data signal being obtained.

In addition to that IMD maintained few permanent small network like 6 station network in Delhi, 6 observatory in Punjab, Himachal Pradesh in 1965, 66 and 3 Jammu and Kashmir since nineteen eighties. This is 2 basically portable seismic instruments they use soon after the earthquake to monitor the aftershock events or something like that. So the all these instruments being upgraded and digitalized ok.

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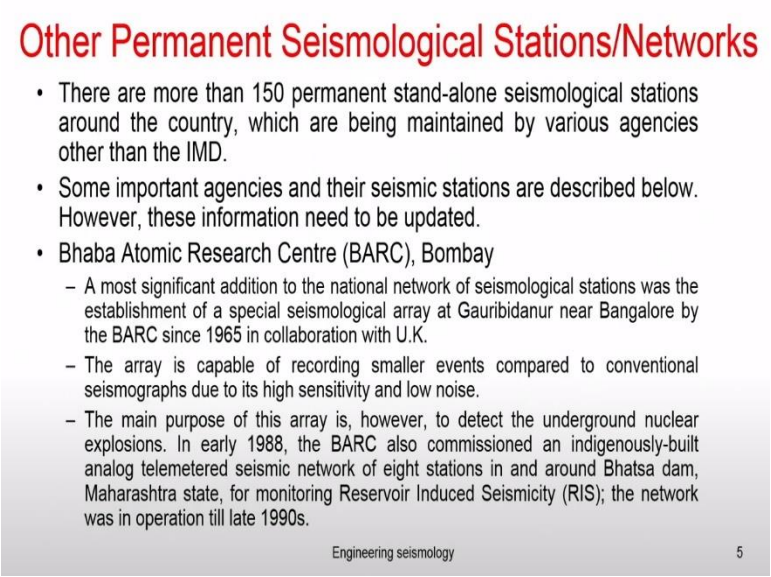

So, then these stations are becoming a permanent seismic station to record data in the country. So there are, more than 150 permanent stand alone seismic station around the country which was being maintained by various agencies other than IMD. So they keep recording the data and independently. So now there are plenty of seismic stations close to like 300 and 400 seismic station throughout the India is available.

But however the station maintained by the IMD is actually the government controlled network. Where those data are even now recently they started distributing to the public for research and development application. So until like 2020 there was no wide availability of earthquake records in India particular. I mean earthquake record acceleration time history or velocity time history not just a earthquake information.

So what you are seeing is so much magnitude occurred at so and so many places is a earthquake information which will not so much useful for the engineering perspective or engineering application. There are many agencies who; started operating the seismic session in the country. So who is some of them who really contributed to the national seismic data? So the first is actually Bhaba atomic research center BARC Bombay.

The most significant addition of national network of seismological station was establish by the special seismological array at Garuibidanur which is very close to Bangalore by the BARC 1965 with collaboration with UK. So this array is recording a small minor event conventionally seismogram is high sensitivity and low noise. This main objective was this array is basically to detect nuclear explosion the India started is direction of research and the nuclear explosion kind of things in 1965 where they try to basically get steady and monitor these kind of thing for neighboring country as well.

So in 1988 the BARC also commissioned an indigenously built analog telemetered seismic network eighth stations and around Bhatsa dam Maharashtra to monitor reservoir induced seismicity. So this was done soon after the Koyna earthquake we will discuss the Koyna earthquake in detail later stage. So after the Koyna earthquake the government in the mostly the people who are holding a big dam states are really concerned.

So among that auspicious the Mumbai basically Maharashtra state they put a reservoir induced seismicity monitoring station under the BARC heading they were they equipped all, those thing.
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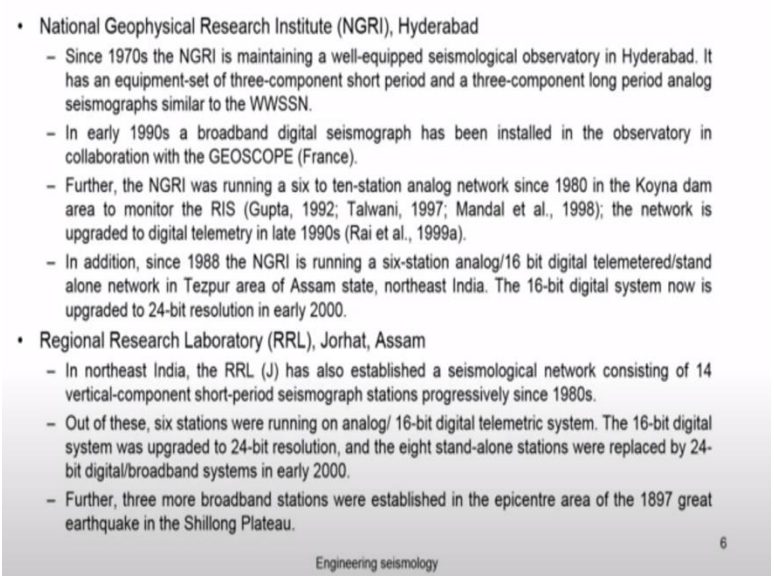

Then the another person who maintain a seismic network in the country sectioning the National geophysical research institute which is NGRI Hyderabad which is short form many of you know that. So in since it is establish in nineteen seventies NGRI is maintaining a well-equipped seismological observatory in Hyderabad. So it also set up a very high sensitive equipment 3 component short period, 3 component long period seismogram similar to WWSSN.

So where they tried to monitor earthquake and try to delineate a seismic source particularly for the important projects like a dam ok nuclear power plants those kind of things they do. In nineteen nineties ok the broad digital seismogram has been installed observatory collaboration with the GEOSCOPE France in the Hyderabad. Further the NGA was running a 6 to 10 station analog network since nineteen eighties in Koyna dam for the monitor the reservoir induced earthquake in the Koyna.

And then the network is upgraded digital later in nineteen nineties. In addition to 1988 the NGI running 6 station analog and the 16 bit digital telemetered standalone network in Tezpur Assam and northeast. And 16 digital bit system now is upgraded to 20 digital system early in 2000. So this NGI also tried to concentrate wherever the big earthquake is there. They deploy the network for a period of like 10 years, 5 years and try to understand the seismic city in the region which will help for the seismic hazard prediction.

So the regional research laboratory RRL Jorhat Assam. The northeast region so they tried to establish 4 vertical components sharp details Seismogram ok. So progressively since 1890 you can see that you can see a single access seismogram as been used in the Assam it is a vertical component that means it does not record in a horizontal component. As you have seen that even though your vertical components are very much important in the wave propagation.

As, you know that the vertical component will be only predominant when you have the close to the P wave arrival to the region or deep earthquake. Out of these 6 stations where, running analog and 16 bit digital telemotor. 16 bit digital system was upgraded to 24 during the 2000 and 3 more broadband where established ok. The epicenter area great earthquake Shillong region in the Assam RRL people ok the RRL people establish the network close to Shillong earthquake region and try to monitor the seismic activity in those region.

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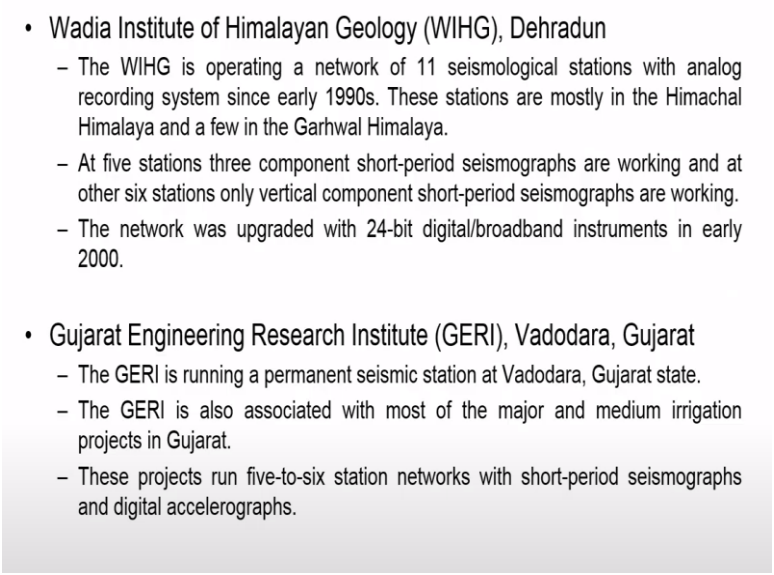

So similarly the Dehradun region the Wadia institute of Himalayan geology so try to establish seismic station at a greater session and try to monitor earthquake in the Himachal region and as well Garhwal Himalaya. The 5 station 3 component short period seismogram is this one. So these are all; the basically regional network you can see that they use short period sensor. Some of theme use 3 component, some of them used single component. So similar to that, there was a Vadodara okay Gujarat engineering research institute.

So GERI is running a permanent seismic station at Vadodara, Gujarat. The GERI is also associated with most of major and medium irrigation projects at Gujarat. This project runs 5 to 6 seismic station with short period seismogram digital network.

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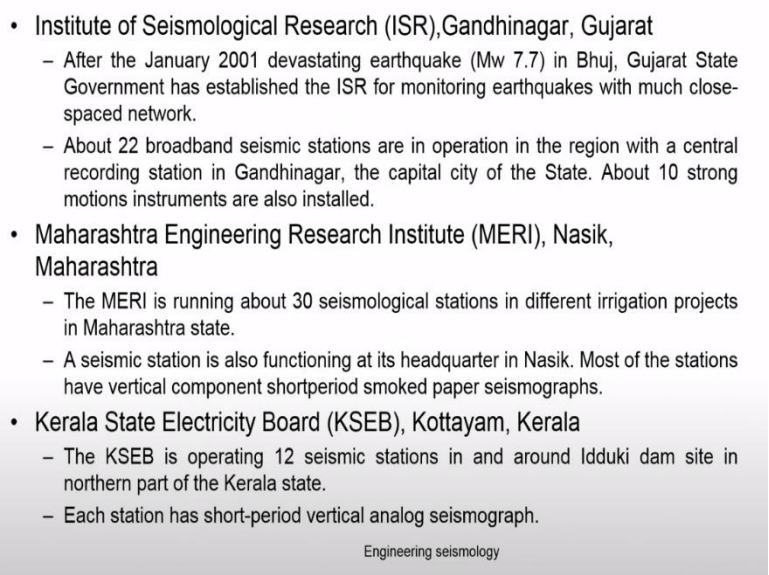

So most of the people when start government started funding the seismic station support, most of the people they tried to establish a close depending upon their institute in and around as well as the facilities what they have in and around. So some of them like dams and geophysical institute like that so in there is a institute started ok after 2001 Bhuj earthquake which is called Institute of Seismological research ISR Gandhinagar.

So where they started running some stations in and around Gujarat particularly Kutch region where 22 broadband seismic stations are operation and region with the central recording station in Gandhinagar capital city of the state about 10 strong motion are also installed. So these are all the places they install and try to monitor earthquake and try to understand when where the earthquakes are occurring.

So similar to that the Maharashtra engineering research institute they also maintain 30 seismology station different irrigation projects. The seismic stations also functioning in its headquarter in Nasik. Most of the stations are vertical component short period smoked paper seismogram. So this Maharashtra one maybe the very outdated old station then similarly Kerala state electricity board Kottayam.

So they run 3, 12 seismic stations around Idukki dam site in norther part of Kerala state. Each station has short period vertical seismogram.

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- Central Water and Power Research Station (CWPRS), Pune
  - The CWPRS looks after two to three permanent analog microearthquake networks consisting of three to four seismic stations in each network in different dam sites in the Eastern Himalaya including Sikkim and Bhutan areas.
- Centre for Earth Science Studies (CESS), Trivandrum
  - The CESS is running one permanent observatory at the Centre using an analog microearthquake instrument.
  - The station is equipped with a digital broadband instrument since 1998.
- Indian Institute of Technology (IIT), Roorkee
  - The Department of Earthquake Engineering (DEE), IIT Roorkee, runs a six station telemetric analog microearthquake network around the Tehri dam, Garhwal Himalaya since early 1990s.
  - The network was upgraded with digital instruments. In addition, the DEE runs several strong-motion arrays in the western Himalaya and in northeast India region.
  - Each array consists of 40 to 50 digital strong-motion seismographs.

Then the central water power research station Pune CWPRS Pune. So look at 2, 3 permanent analog micro earthquake network consisting of 2 to 3 seismic station in each network in the eastern Himalaya including Sikkim, Bhutan for the water related project. So the center for earth science studies is Trivandrum. So they run some earthquake station to Trivandrum where the southern area so some of the stations, are operated.

So IIT Roorkee they have taken a big initiative where the department of earthquake engineering IIT Roorkee runs 6 station telemetric analog microearthquake station network around the Tehri dam, Garhwal Himalaya network was updated to digital and try to monitor they try to establish a big network in the Himalaya region about 5 years back. Then they also handover that to the IMD followed by that.

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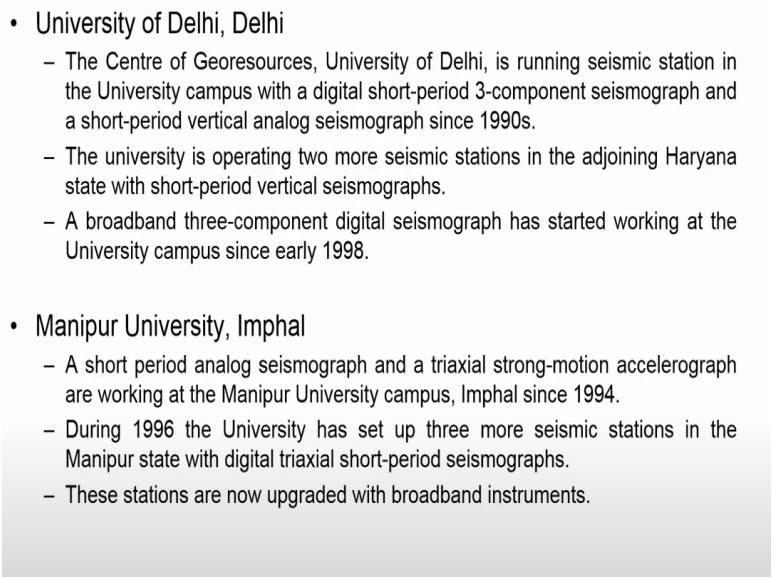

So similar the university of Delhi they try to monitor some earthquake in and around Delhi and installing the so seismometer short period long period. And Manipur University Imphal they try to install some session in and around their region they try to monitor earthquake.

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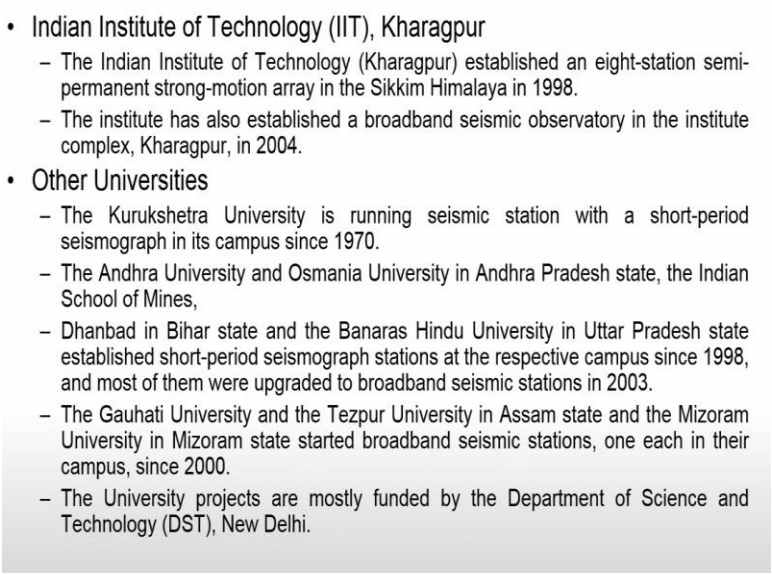

So even the IIT Kharagpur ok they install and maintain some session in the Sikkim part of the Seismic (()) (28:40) Sikkim city. So there are other institute we run like Kurukshetra university, Andhra Osmania University ok then Dhanbad Bihar state, Banaras Hindu university Uttar Pradesh and then Guwahati university, IIT Guwahati, Mizoram ok. Even IISC has some kind of seismic station installed and maintained ok. So if you see that the country has try to establish a seismic station after nineties.

So you can see most of the seismic station where they start installing by the time the world was got very advanced seismic instruments ok. That is what we can notice and most of the instrument what you can see that many of them having a vertical component which is according to me basically which is not so much useful for the understanding the wave propagation. As you know that some of the wave may not be completely represented in the vertical component seismometer.

So this was the status of seismic instrumentation in the country. But now has on all the permanent station ok it will be controlled by the IMD Indian metrological department. So where they basically upgraded the many of the old station and try to record the data and try to report to the universal values rather than this one. So there was many places where they start seismic instrumentation and establish after that there is no maintenance and report.

So as I can say that until 2020 India has very limited access to the earthquake recorded data such as the acceleration times t velocity times t in the world earthquake because of poor and improper management of the seismic station in those days. So with this we will close we will go the IMD seismic station in the next class. So thank you.