**Coastal Engineering**
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**Module - 9**
**Tsunami**
**Lecture - 2**
**Tsunami – II**

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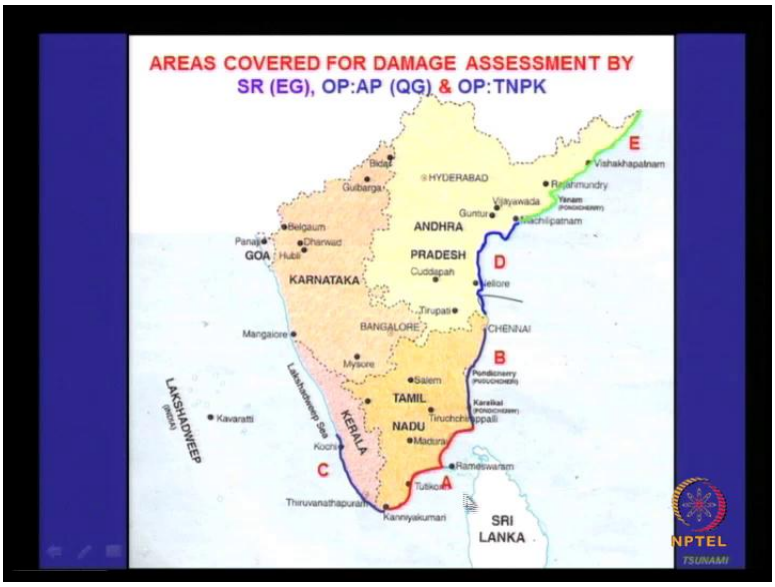

During the tsunami, the affected parts very badly affected were the ones, which are shown here in blue color. So, all these places were affected and a bit affected were this much but it was not much and this was really not affected much, because it is in the shadow area of Sri Lanka.

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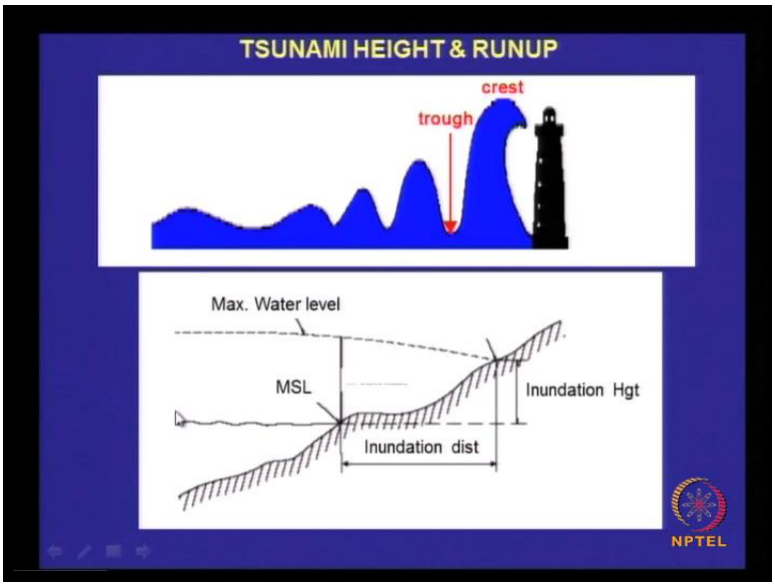


So, this shows that, this is the MSL elevation that is, mean sea level, when the maximum water level comes usually, it may be somewhere here. Mean maximum water height mean sorry maximum high water line may be somewhere here, may be may be somewhere here its only approximate representation. But during a tsunami, the maximum water level can may be much higher which means that it will run, it will reach the land point somewhere here.

So, where it reaches, this is going to be the inundation height measured from the mean sea level and the inundation distance is measured from this point to this point. This is very important, this defines the inundation height and the inundation distance.

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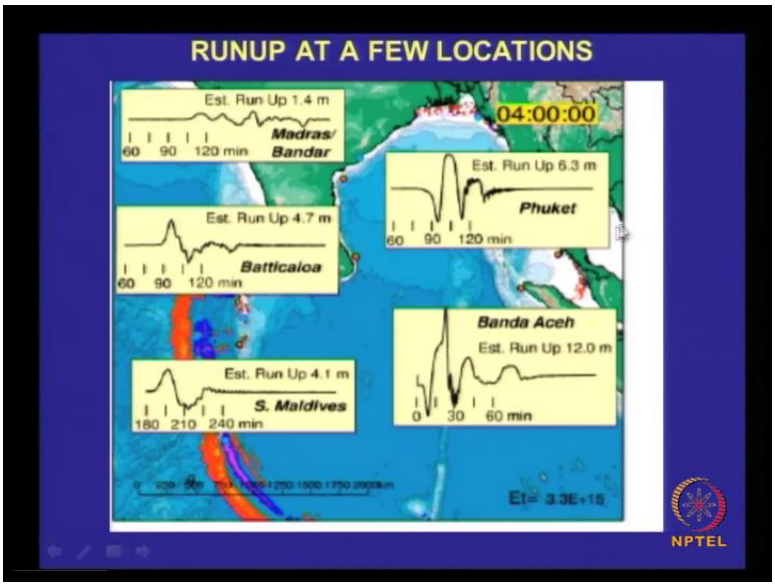


Run up levels at few locations during the tsunami are indicated here, one is the Chennai then you have the Batticaloa that is in Sri Lanka, Maldives then this Banda Aceh 12 meter then Phuket and that is at 4 4 hours.

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So, this shows some of the video clips during that appeared in the TV and in the net internet that, how the propagation of the tsunami in Penang that is in Malaysia then Indian tip of Indian peninsula. You see that, so before the ingress, so much of land was exposed, sea bed was exposed, that is not the usual, that is not usually the case.

So, there were about 500 meters of land was exposed to the Kanyakumari and then you see that, the waves reach the almost the pedestal of this statue and the splash hit, even the head of the statue. I just leave this so that, it gives the idea concerning, how devastating was the tsunami you so you see the waves coming here that is the, those are the tsunami waves. There are so many incidents, that the people got draped under the, near that area all those things but I do not want to go into all those details.

So, you see that here so it reached up to the reach the pedestal of this statue, is it clear so but there were some other movies taken wherein, you saw the you can see their water level going up to the head but it was only the splash. And after this, you see the, how the boats are moving and they go on collide with each other and that, has resulted in a huge damage to the fishing community.

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So, now, this is somewhere in Sri Lanka and this is somewhere in Thailand so these are so you can see the pumping of waves into the land, I just I will run it once again. So, there are some causality in both the locations and all the locations are, they have some causalities, I am just showing only some clips because although I have all the other information, it is just to make sure that, you have some kind of an idea.

So, you see the ocean water entering in the swimming pool of the hotel that is, in Sri Lanka, so you can also feel for the field, the speed with which the water level was moving right.

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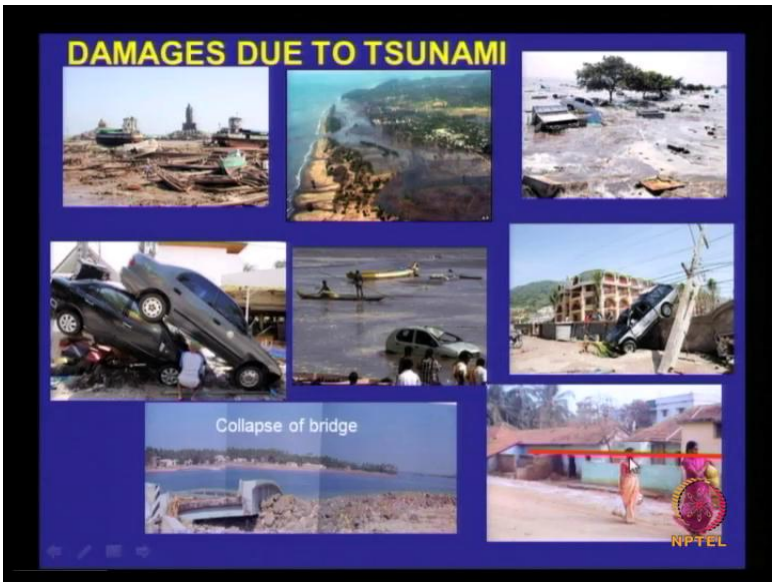


So, damages due to tsunami, this picture is almost all the glimpses of their damages, that were caused along the Chennai coasts, are shown here. So, you see the vehicles just lifted and floating and then here is the coastal flooding this is this is the coastal flooding and this is the tip of Indian peninsular where, you see the boats going and hitting against each other, it got damaged. So, here again a bridge and nice bridge got collapsed and then somewhere this shows at certain locations where, this is the red marks shows the level of inundation, the height of inundation.

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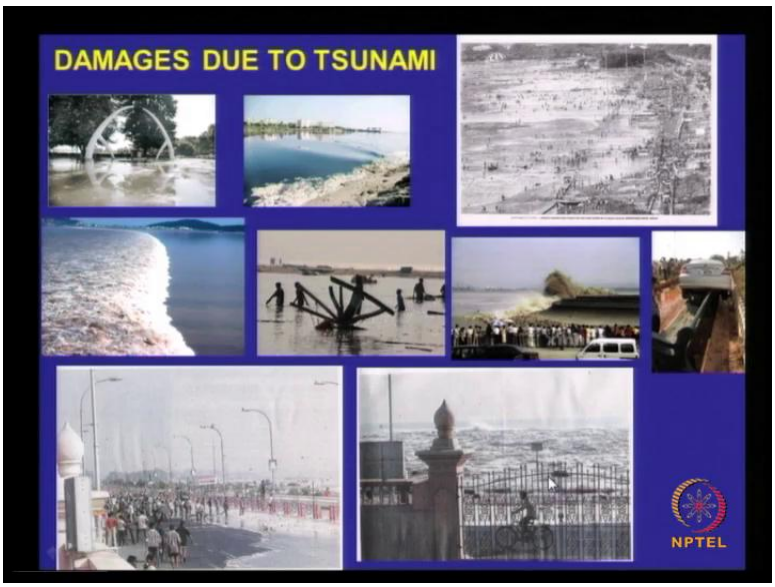

So, again somewhere, this is the city of Chennai where, you see the flooding in the marina beach and you can see water level, somewhere in the Chennai. So, you can see the all thing.

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So, the marina beach, imagery tsunami impinge on the marina beach then effects of the coast line.

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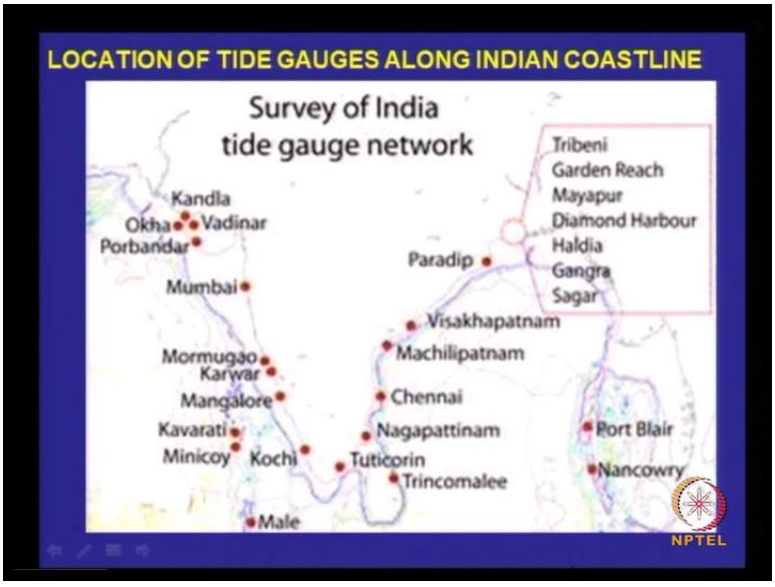


So, locations of tide gauges along the Indian coast line so if you look at the Indian coast line, we have tide gauges all along the Indian coast. So, so during this propagation of

tsunami, what happened, all this gauges, the tide gauges will certainly record the water level but what happened we will see here.

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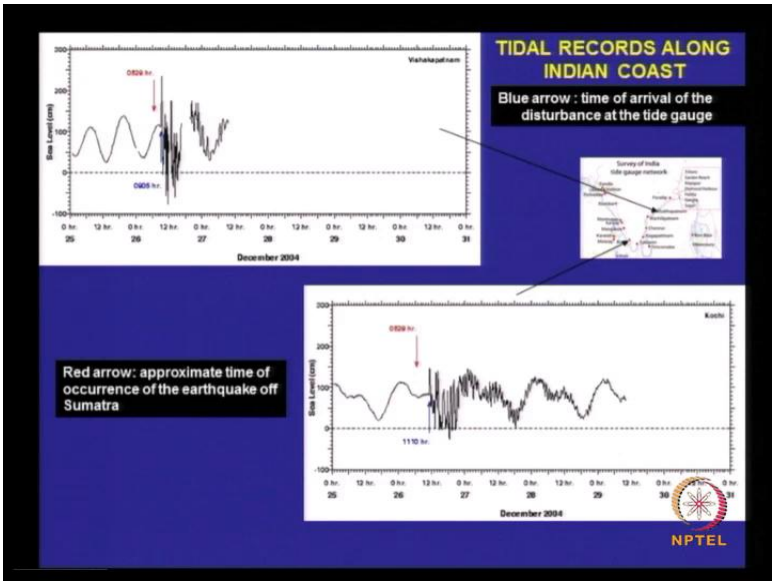


So, this is the this is Vishakhapatnam, this is I think cochin so you see that all this blue arrow at the time of arrival so time of arrival is this one and the disturbance. So that, before that, you see all the nice, smooth recording of the water line water surface elevation but you see at the time of arrival of the tsunami, this has failed.

That is, it has stripped that is, the tidal gauge did not have the capacity of recording of water level beyond that. So, I understand that the range of measurement of this was only 3 meters, and so that means the water level in these locations might be more than 3 meters at that point of time.

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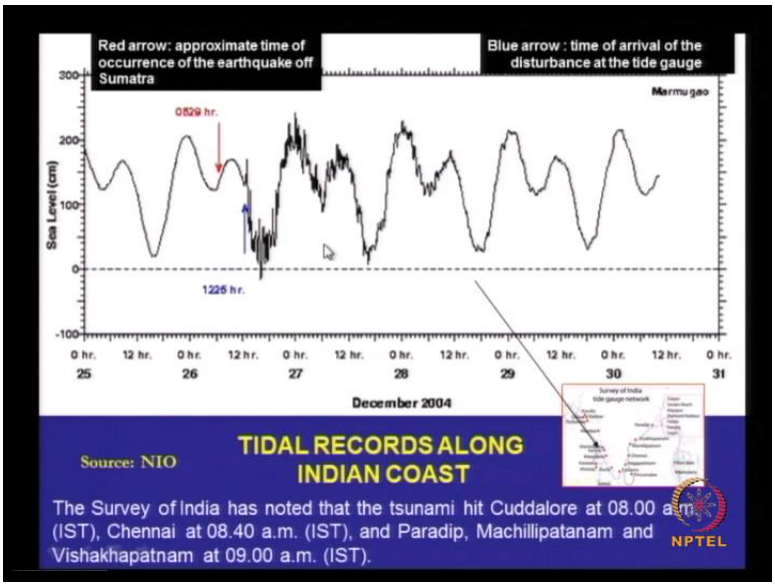


So, even Mormugao did not record at the time of failure because probably this failed your it failed to record the level slightly more than, what it is supposed to record.

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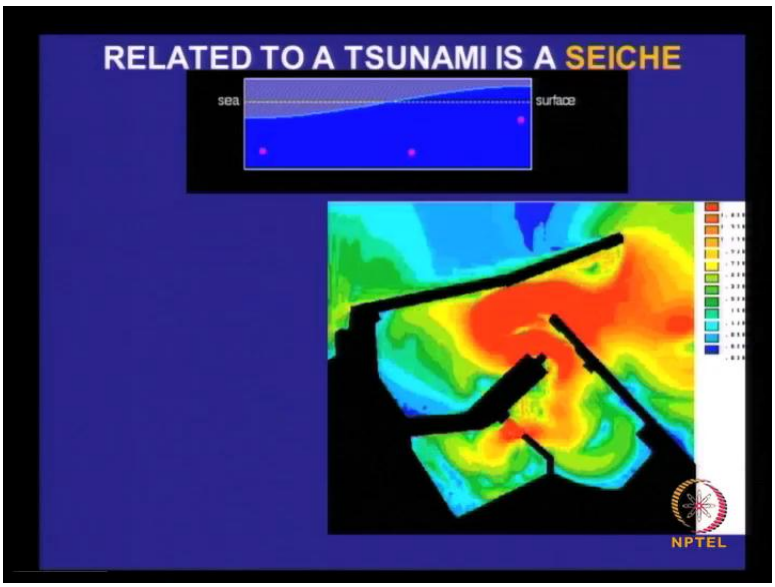


So, apart from that, this is what happens, I have been telling you earlier that, once a long period wave enters inside a harbor then it is a big problem. So, this is basically a long period wave when it is when it has entered inside, the disturbance continues. When the disturbance continues then the collision of the boats, vessels has all these things will take place and that is going to be a catastrophic.

And this is how, the oscillation will be very slow oscillation but then this is good enough to snap the mooring lines and leading to other kind of damages.

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So, this is a movie soon after the tsunami that is, in Nagapattinam, Nagapattinam is south of Chennai where, that was very the very badly affected area. So, you can look at the kind of devastation, the boats which was supposed to be in the harbor, are all on the birth and this is very badly affected.

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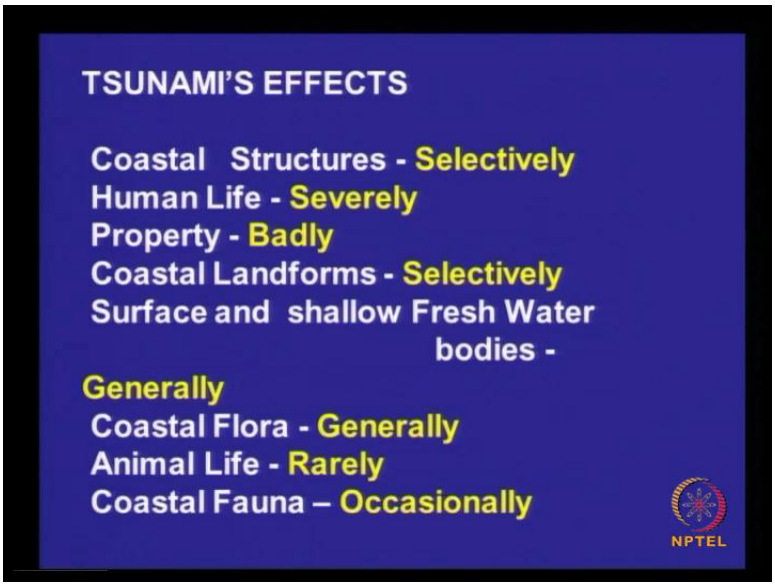

So, tsunamis affects coastal structures selectively, human life very severely, property property very badly, coastal land land forms selectively. So, surface and shallow water fresh bodies generally, it was affected, coastal flora also was generally affected but not very severe. But surprisingly the animal life was rarely affected because they had the sense of knowing that, something hunt word is going to happen an natural calamity. So, there were not much of problem with the animal life, coastal fauna here and there, it was affected.

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So, major impact in the foreshore, modification of the beach front, concentration of heavies, heavy minerals deposit as a places, then breaches in the beach ridges then flattening of foreshore and adjacent areas.

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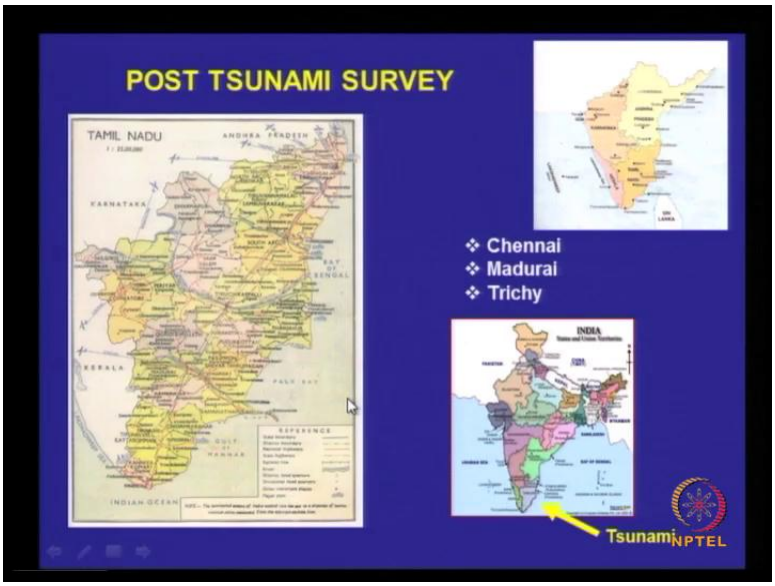


Now, we have done the post tsunami survey so this is this is the map of a Tamil Nadu, this is the affected area and we are somewhere here, this is the Indian map and we are somewhere here and Nagapattinam should be somewhere here.

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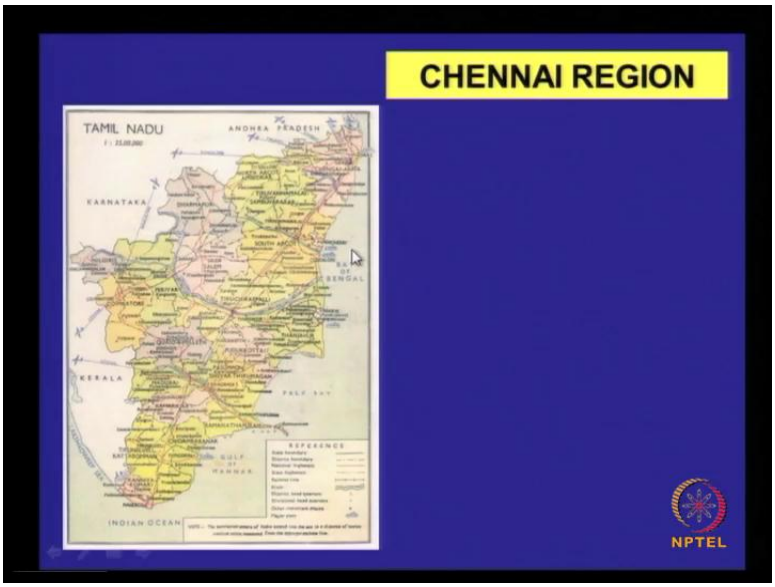


So, let me call let me just show you about the Chennai area, Chennai area is somewhere in this location, this is the stretch for Chennai Chennai region.

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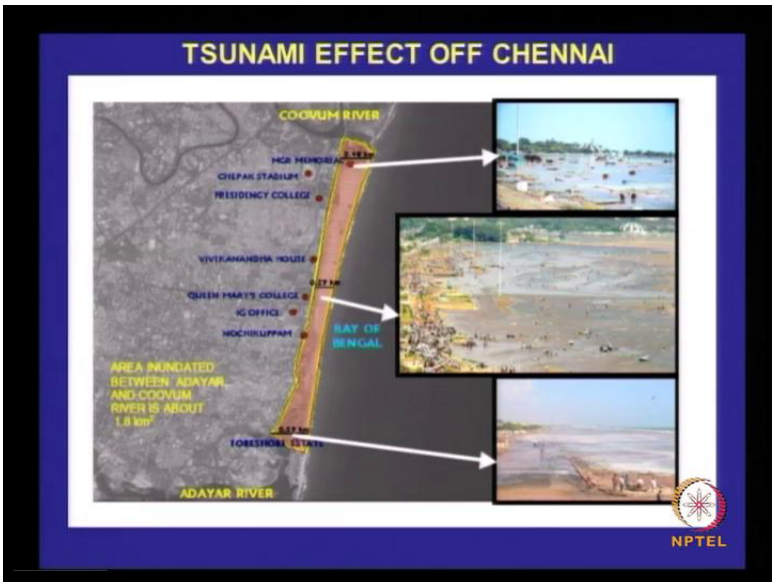


So, we did. So, the marina beach, one of the longest beaches in the world so you see that, this is the kind of inundation we have, the area inundated between Adayar that is somewhere here at to Koovam river. So, this is approximately 2.9 kilometers and this is approximately, I think these 0.29 kilometers 0.3 kilometers and this is around 0.5 kilometers.

So, that is the kind of inundation they had got, as this map I believe it has been done by Anna university or one of the institute, which is involved in the GIS and remote sensing and some of these pictures have been borrowed by from some friends.

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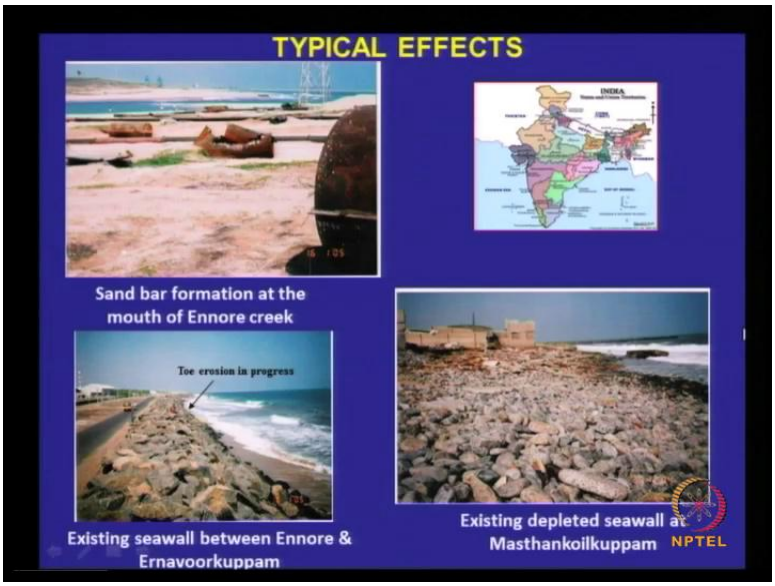


So, you see that, one good thing that happened was, the opening of the river mouths, which is always perennial problem of sand bar formation, which we have already seen earlier. But during the tsunami, that was only plus point that, it is it got removed and the toe erosion, that was one serious problem that, took place during the engraves of the tsunami. So, this toe erosion because when it is retrieving, when it is going back, you on the sea on the land side land width side of the sea wall, see this is a these are all soft soil you know, it is only a sand.

What will happen, with the velocity is created, this will drag and there and also there is some amount of draw down, I mean draw down here. So, all this will pull the sand inside and creating toe erosion, and there was lot of damages to the sea walls, which we will see later.

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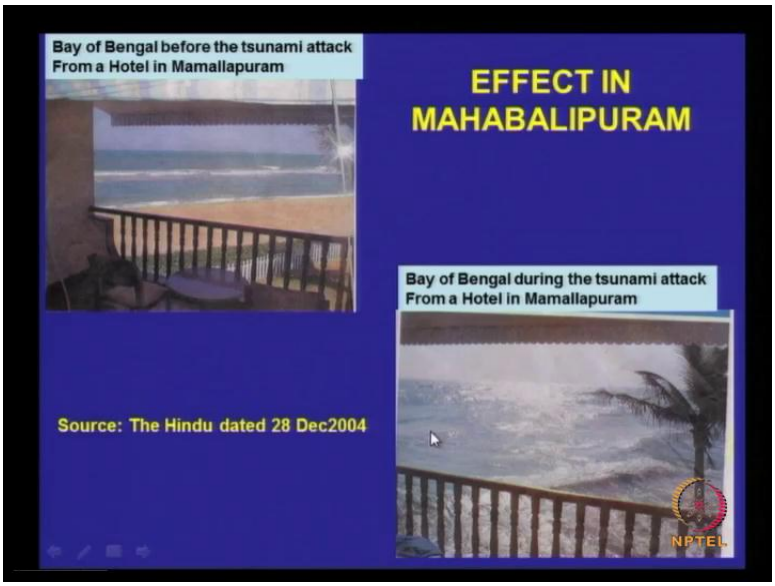


So, this is in Mahabalipuram, a famous tourist spot and this is how, it looks during the tsunami from the balcony of a hotel. So, where you could see the beach, now see only waves.

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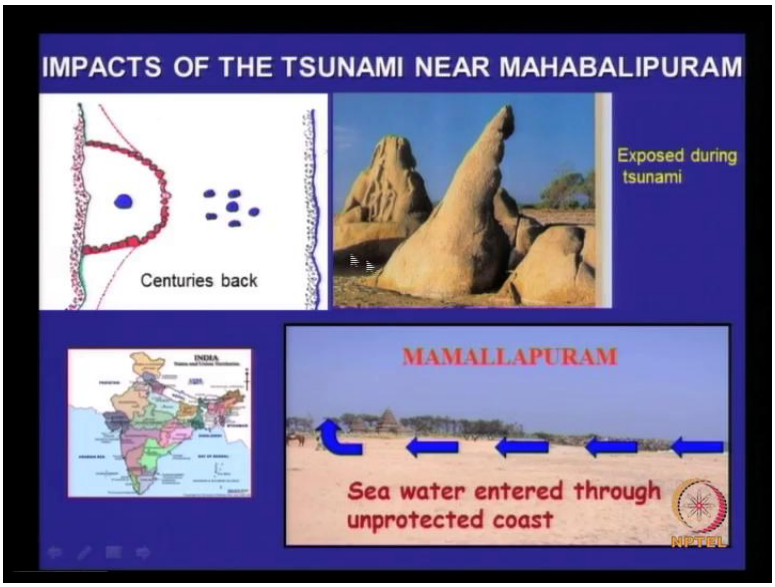


So, effect of Mahabalipuram so this is Mahabalipuram a case study, which we have already seen during our in the lecture on costal protection. Now, here during, as I said there was water, which is receded, the water level receding into the ocean. So, this

exposed some of the relics, century back there were some temples and other things, which were which got which got sunk buried.

So, those were exposed during the tsunami time, so during the this is a flat area near Mahabalipuram.

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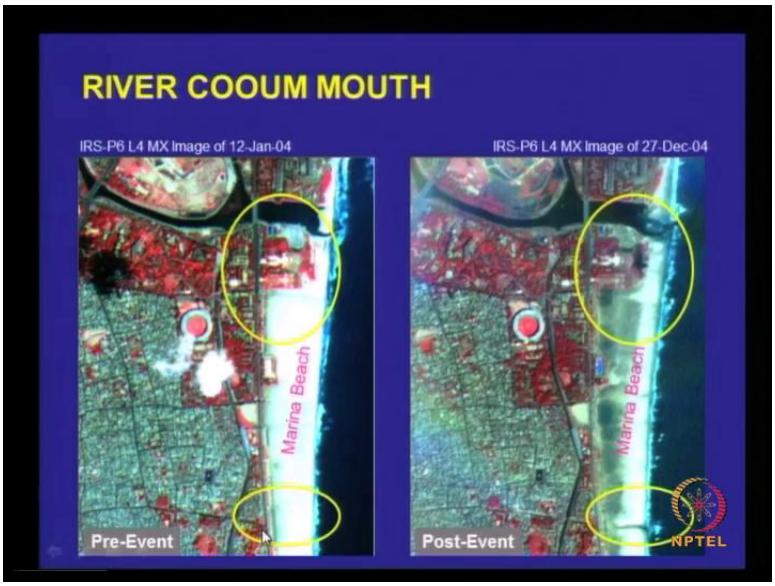


So, the sea water entered through the unprotected coast and then there was some problems in this stretch of the coast. As I see, this is the major problem, one of the river which is draining into the Bay of Bengal and it runs through the city of Chennai. And its always perinea, it has been a perineum problem for decades, that that is a closer of the river mouth living, which is quite sad for the entire city of Chennai. Because this is going to this is this is being served as a stagnant pool of water, for the breading of mosquitoes and there are other associated problems.

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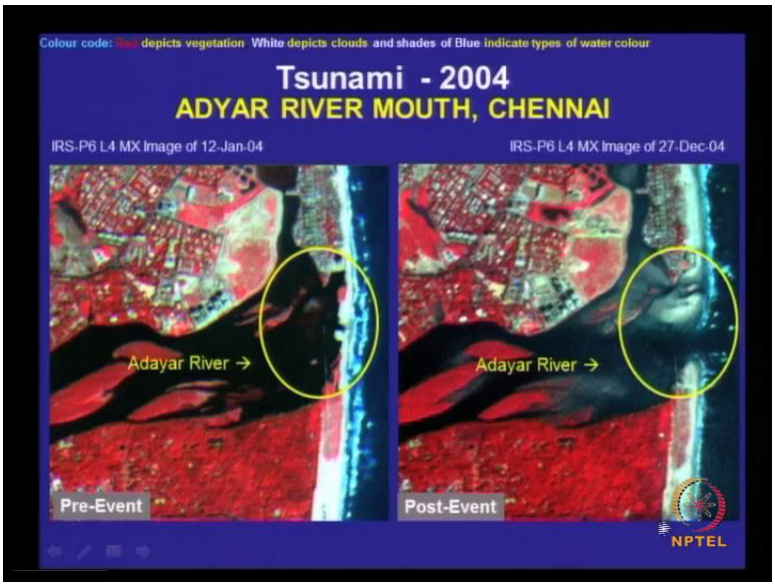


So, this was this is always close now, during the tsunami, you see that it is opened and even the Adyar river was open, as you can see here. A closer view of the Adyar River always closed by the river sand bar formation, but during the this one it was opened.

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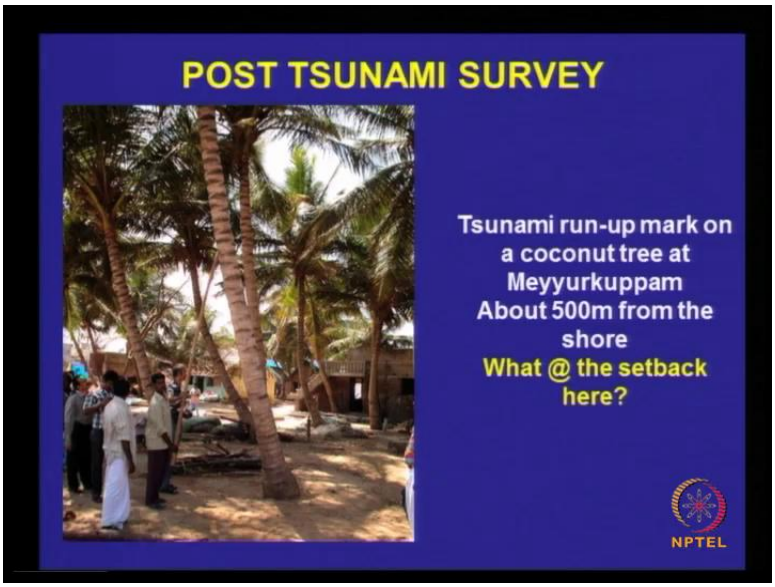


So, we did the tsunami run up mark see for example, we identified the coconut tree in one of the places and about 500 meters from the shore, what is the set back here. So, I will come back to the set back line later because how close the people can put up the dwelling units from the coast, this is one important issue, which needs to be discussed.

Because they say that you should not construct any building within 500 meters but that rule cannot be really applied.

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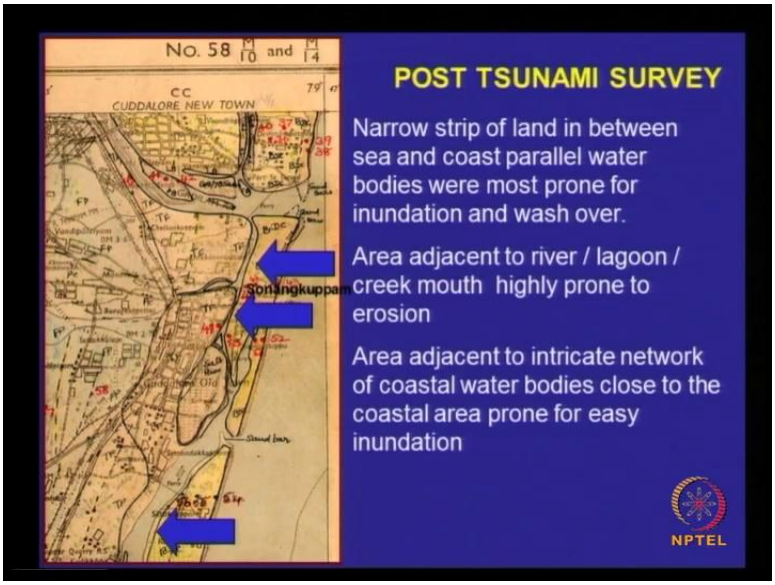


So, I will I will see the effect of all these things, I will show you all the effect of all these things later. We will discuss about the coastal regulation zone towards the end of the talk.

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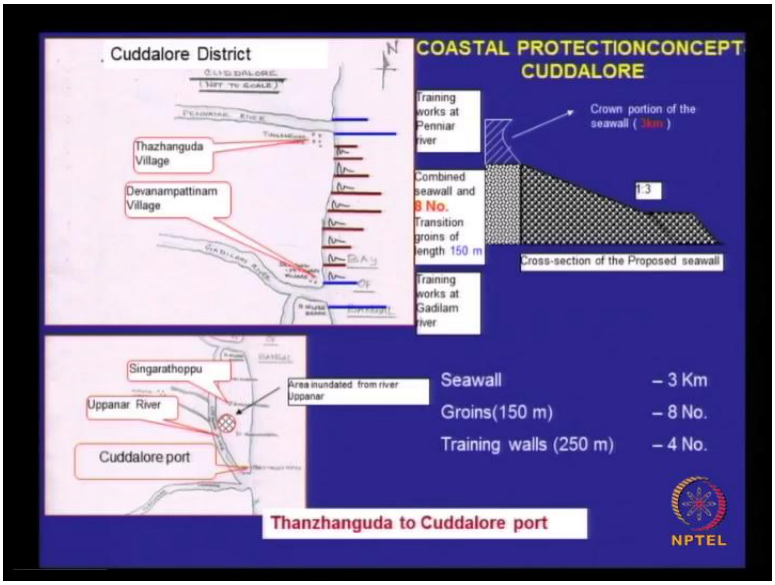


So, there are other locations where, we had a had a close survey and one such a location is something like this where, there were lot of problems, Devanampattinam. There were

about 80 to 80 causalities and this were also, somewhere here also there were several causalities here so this stretch of the coast is very important. So, what you do is, you and this is the river and this is also a river, the initial idea was to train this river to train this river.

So that, the sand bar formation is removed and then the both the rivers are free so that, it need not have the stagnation problem and then the sand bar formations associated. So, that is one thing and then in between them have a transition groin field and also associated with a bund like this sea wall. Where, the all these things are only a conceptual design. But the detailed design has to worked out, this is only a conceptual design.

So, like this, we had done a several stretches along the coast, we have identified where, exactly you need to going for sea wall where, you need to going for training walls or groins, etcetera and what were the priorities etcetera, this is the major report that has been prepared.

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So, look at this, when you have a flat beach as shown here, this is a one case where, it is this place is called as Thirumulai Vasal Thirumulai. So, this area, so look at the road there are lot of causalities here, in this location and this is, it has never occurred like this, never in history. So, you look at this because this being a flat beach, flat beaches are very

dangerous locations as far as tsunami is concerned. So, you need to safe guard all those areas so you I allow this movie or the clip to move on.

So that, because you again see the road a permanent road a metal, I mean a permanent road now, looks like a river and I believe that this location at this location, you had some the inundation distance was something like 2 kilometers, 1800 meters to 1.8 to 2 kilometers. So, I allow this to move in fact, there was a video for running for about, it was running for a quite some time, I think may be 1 hour or 1 and half hours.

And I just had a cutting of this, that was very sad because the whole thing see the once it was looking, once a road now, it gives an impression that it is a river, any of you have seen this. So, now, you get an idea right, what was the 2004 tsunami at least people who have not been staying near the coast. So, this was one problem but then again when it is receding that is, going back, it took away a lot of debris and other things and create a lot of problems.

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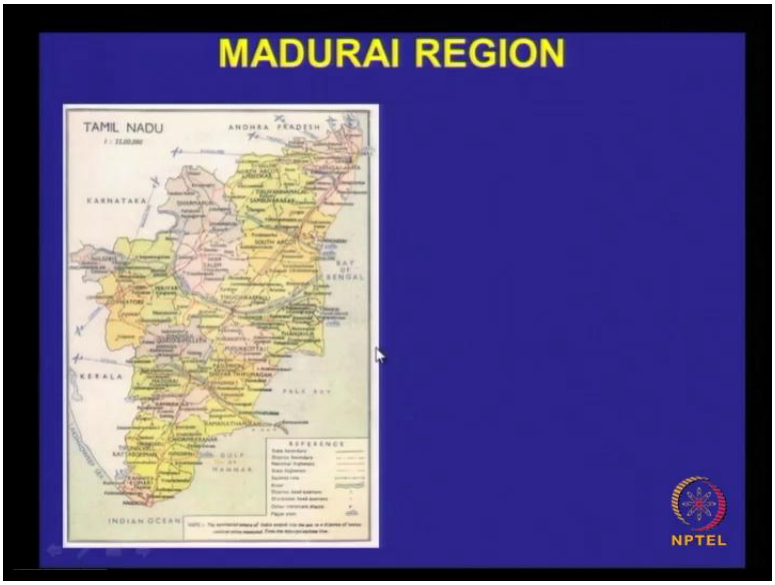


Madurai region is somewhere here Madurai somewhere here, not the park state, somewhere near Madurai.

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So, somewhere again south of the Chennai region, you see what has happened so this is another movie, this place is called as Aalanthaalai. So, where in you see the continuous pumping of a sea water into the ocean and what kind of engineering solution, you can really think off, when you have a such kind of a devastating force. So, very very difficult to really design anything for this, it is quite massive, later we will any way look at design the estimation of wave forces, on vertical wall structure etcetera. But I do not know, how to deal with this kind of waves, what kind of wave so continuous.

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So, as I said earlier so they see the bridge completely collapsed, the sea wall disturbed completely then all the river mouths opened in this region. That is, velar Madurai region is slightly south of Chennai now, far away may be around 300 kilometers 400 500 kilometers may be.

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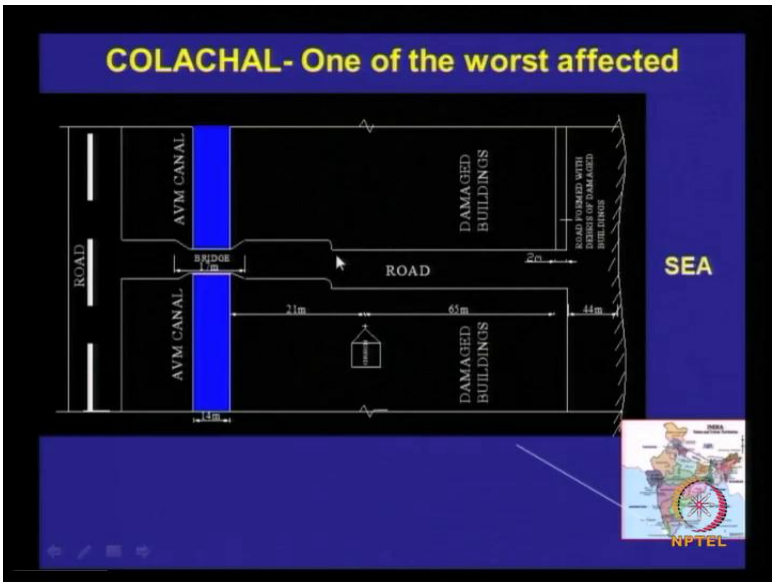


So, you see, all this opening of all the rivers and this is one area where, it was quite devastating so this location is somewhere, shown here in the Madurai region. So, you see that, there is a this is the sea and (Refer Slide Time: 22:43) this is a canal and this is the road and this is all flat wherever, you have flat beaches, it is very risky. But here, this road is at an elevated level, if all this people living here had manage to run into this road, most of them they would have saved because slightly beyond the road also there were some elevated areas.

But, what happened is, it was a pity that, there is a canal here and you have a bridge and when the water comes, you do not know, you are running complete without any aim, only the only aim being to escape. And all the people rushed in sand and they lost the track and many of them, they got trapped in this canal. And this is the AVM canal, which was very, very much referred during the period of tsunami where, they had a lot of people, who got drowned into this AVM canal and this entire area completely washed off.

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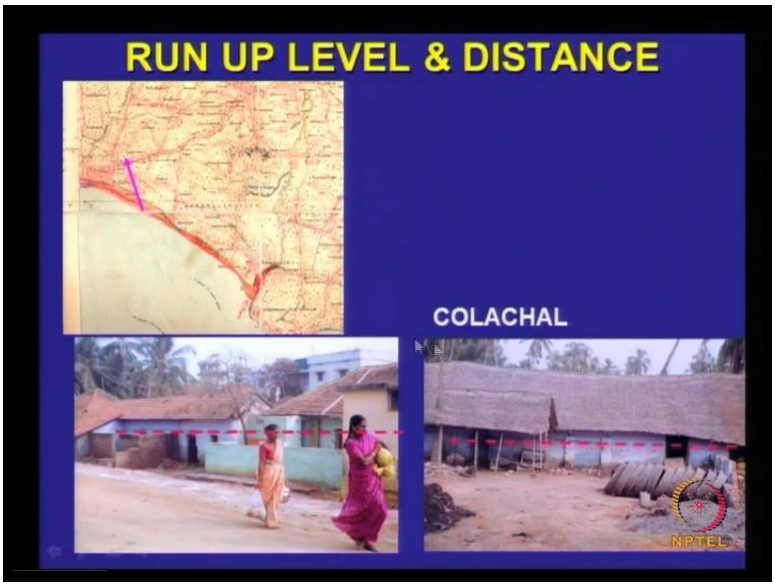


So, this is the area where, I said this is far away from the beach where, you see that about a 5 feet of water has come in.

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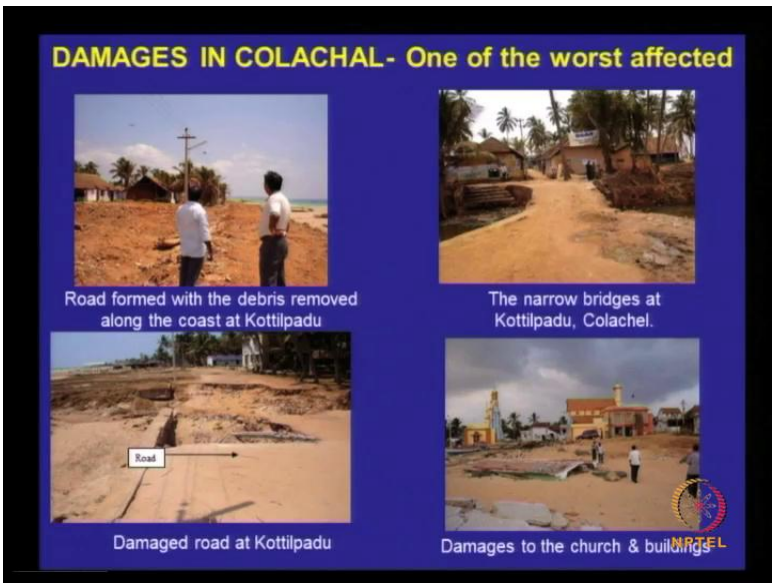


So, this is the bridge, I was referring to so the level is almost the same, as that all through till the beach. So, the all this things have got eroded or completely damaged and you look at this church building, entire church building has been damaged. And I believe the water went up to the ventilator of this church so you can imagine the kind of a problem, they would have faced.

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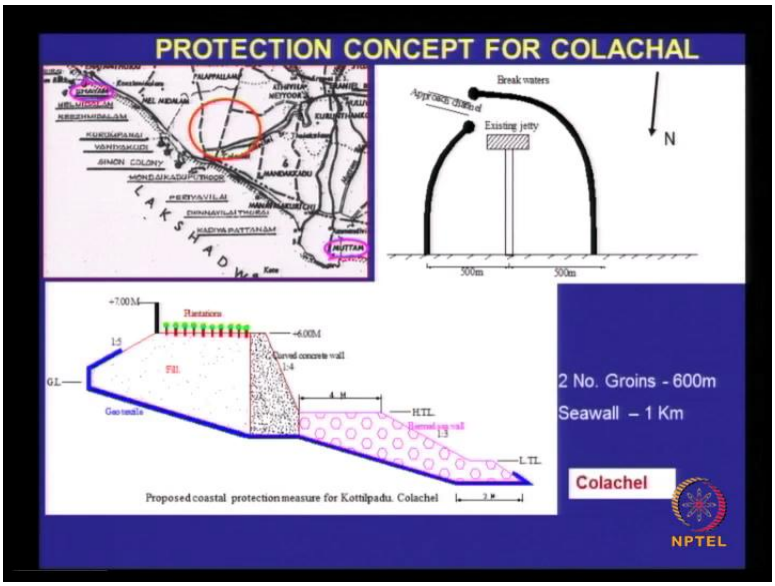


So, what is the kind of solution, you can think for this kind of a problem so what we thought is, we had an idea there is an existing jetty. We need to a tie because what is the guarantee that, the tsunami is going to occur in next 100 years, there is no guarantee. Whether it is going to occur tomorrow, we do not know whether it is going to occur, whether if at all it is all is going to occur next 100 years, we do not know.

So, are we supposed to keep quite or are we supposed to spend money and do something so this is a very important topic a very important and very tricky topic, which we needs a lot of debate and discussion. So but our own idea was, that we looked at the some of the problems locally so they have a jetty here, they have a jetty which they are not able to use because of, a higher level and because of, the disturbance because it is open. If it is a open jetty, they cannot come and birth the vessels because the vessels will be in oscillation.

And this is an area, which has taken away about 100s of lives so what was thought by us is around 1 kilometer or 1 and a half kilometers, the affected stretch needs to be constructed like this, having a sea wall but prior to that have a pair of break waters. The alignment is not 100 percent fixed, it is only a concepts, we need to do the detailed engineering. So, have kind of a pair break waters, facilitate the usage of the existing jetty and enhance the livelihood of the local community, and then along with it have a kind of a structure similar to this or less expensive.

This may be a bit more expensive, it can be less expensive or just a sea wall of curved section, etcetera all those things can be thought off, only they make sure that this top level is kept at least up to about 7 meters. So that, they will not the inundation can be much less and also have a some kind of plantation, so that it can reduce the speed, with which the water is moving in.

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So, this is the retreat of the shore line at Tiruchendur that is, again south of Tamil Nadu south Tamil Nadu so it the sea bed exposed. So, this is the original scene prior to the tsunami, on the same day. So, you can just see and all this area has been exposed now.

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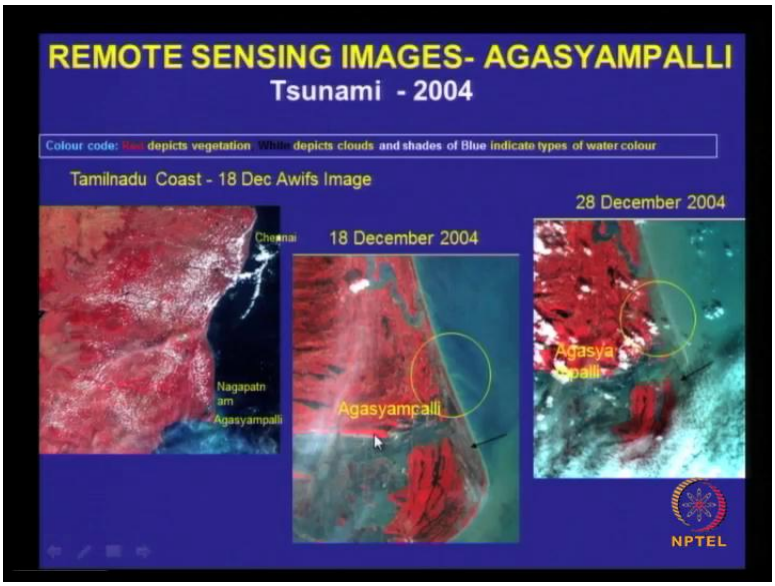


So, this is yet another along the Trichy region, along the Chennai I mean, Tamil Nadu so all this remote sensing imaginaries, you see that, how it has inundated some of the locations at different places.

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So, you see Chennai is here and all this places are here and some of the shielding effect, this is the place where, you had a lot of damages, this is an damages in Nagapatinam. So, for people who are not familiar with where, exactly is Nagapatinam, please go into the Google and search yourself, it is not take much time.

So, use Jhoog concrete bridge girders got collapsed and that is very much inside the town thickly populated town and some of these areas where, they immediately thought of some kind of a plantation. But I do not know, what is the status as of now so some other damage portion of the vertical wall, there is a vertical wall also, which was damaged, I do not want to go into the details.

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So, this is an area, which is called as Keechankuppam, which was badly destroyed because many people about 300 people lost their life and then.

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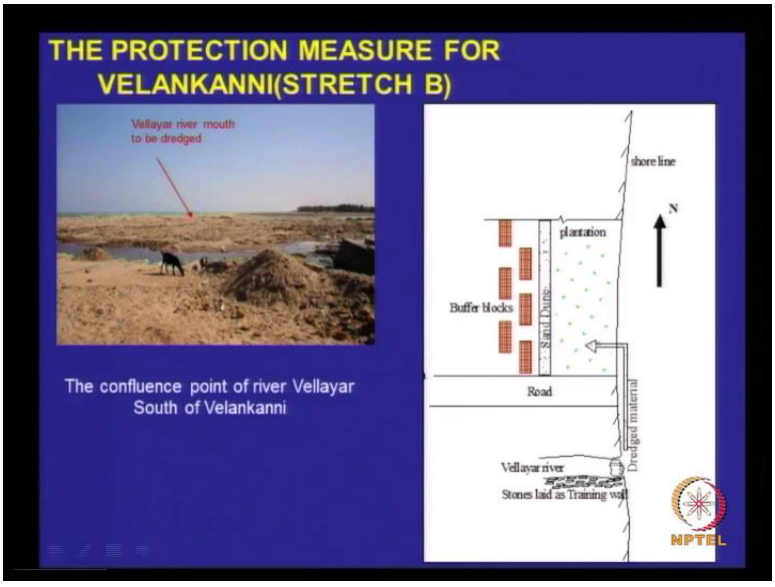

So, we have suggested some remedial measures for this and one one one of the another area where, around the same location is the Velankanni, famous Velankanni church is there. So, somewhere (Refer Slide Time: 29:23) here is the church, somewhere here so there is a road leading and there are lot of inundation here. So, the idea is to dredge this vellar river, take this sand, put it here, just in front of the church. So that, it is saving in case of event like the extreme flooding, it can save to some extent, act as a buffer.

So, we have the plantations and a sand dune here and then have buffer blocks something like seating arrangements. So, that in the event, there is event like tsunami, it has to go through the plantation then over the sand dune and then later on if wind reach this buffer blocks. So, buffer blocks are staggered so the velocity will drastically reduce that is, the idea and we make use of cleaning of this river. So, wherever we have the rivers adjoining there, this is this was suggestions that remove or clean the river mouth.

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So, some of the locations where the impact of the roads, now we move on to the west coast.

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So, as you have we have seen earlier as we have seen earlier, the east coast because of, the Sri Lankan island, the diffraction took place and hit Kerala. These were all the areas, which was which were affected that is, in Thiruvananthapuram district, Kollam, Alappuzha, Ernakulam and Kanyakumari district. So, all these places where, the thick one shows the thickness shows the intensity with which, it was it has taken place hit the coast.

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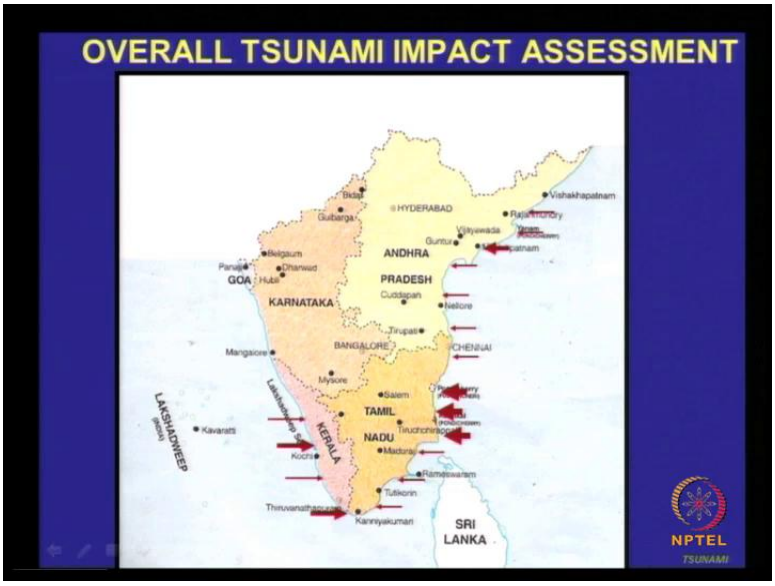

And here, again the whole thing, the overall tsunami impact so here this is the area, which was very badly affected and followed by these two areas and then machalipatnam was one area which that was affected, and all other areas were not much but they had their own impact.

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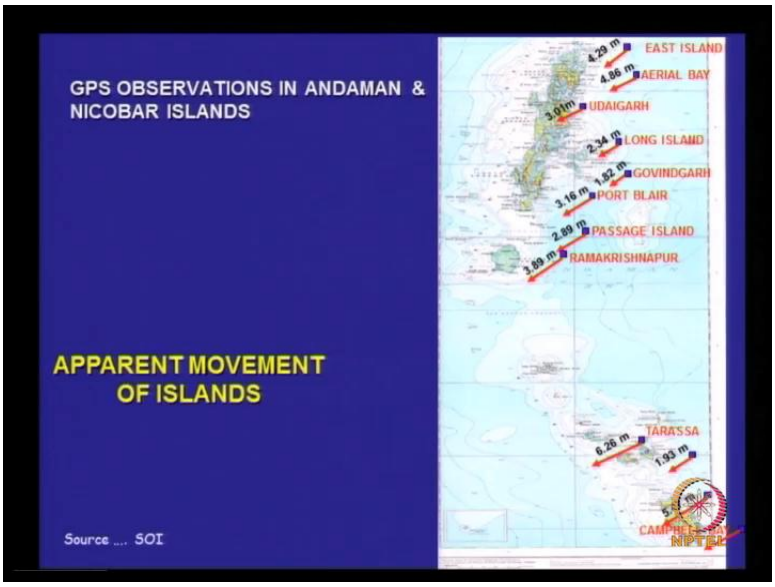


Moving on to Andaman and Nicobar islands, GPS observation in Andaman and Nicobar apparent movement of islands, they were they have predicted that the islands itself has moved in the direction, as indicated by the magnitude, as indicated in black colors.

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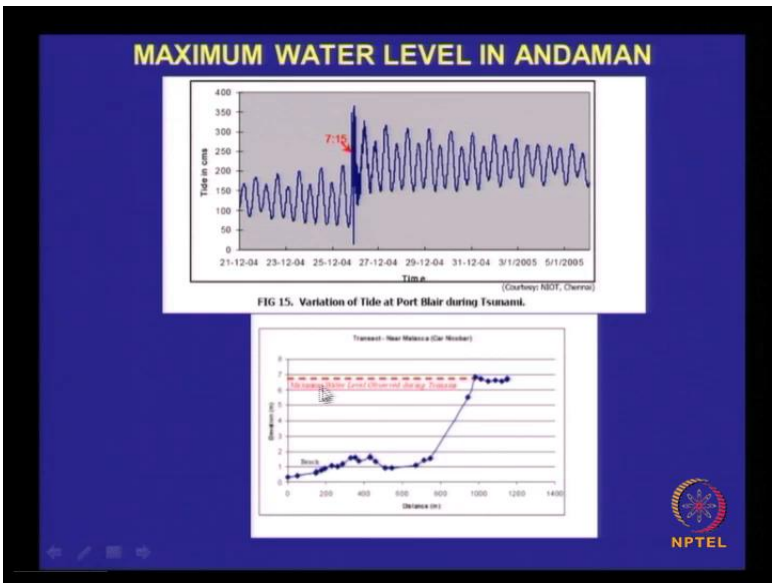

Maximum water level recorded in Andaman is, as you can see here about 6 point, almost close to 7 meters, 7.1 around 7 meters, some of the cloud imagery not clear. But here look at this, this is the one, which was completely cut the entire island, the one piece of island is almost devastated by the and here again. So, such informations can be obtained by from the satellite imageries and this is damage to the properties.

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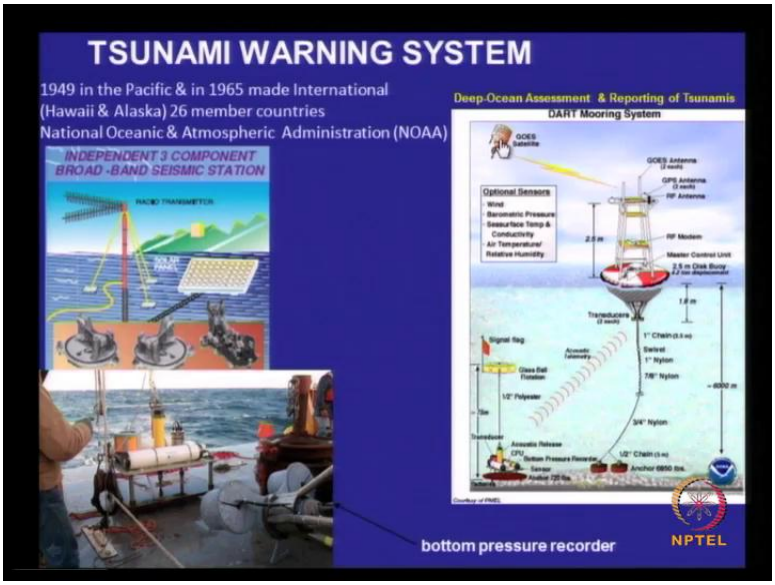


And now we come to tsunami warning system, what is the kind of warning system you can have, see one of the basic difference or the main difference between a normal wave and the tsunami is, it is wave period. It is it period as explained earlier, the wave period is in terms of seconds or in the case of a wave, and it is in the case of a tsunami, it is hours. And in terms of length, it is in tsunami in the case of about kilometers whereas in the case of a wave, it is meters.

So, when something when you want to measure the pressures, you know that the pressures exerted by a long period waves are more, we have seen, we have a worked out problems also. So, when a long period wave goes, there is an alarm or a trigger given to you, if you are able to have something in the beneath the sea bed, as you see here, you have a pressure sensor here. And when there is a wave moving on the surface, the pressure sensor will sense the pressure due to the wave and sense it to the monitor system that is, to the wave rider buoy.

And by the form the moved buoy, it the signal is passed on to the satellite and from the satellite, it can be sent to the on land station, that a wave that of pressure of this much has been sensed by the pressure sensor. So, the pressure the went up to about 30 seconds, if the waves are moving, you know what is the order of pressure, that the pressure sensor pressure were near at the sea bed, for that given water depth.

So, you know what should be the maximum pressure for a given water depth but if it exceeds that pressure then naturally you can easily suspect that, it is something going wrong, may be a tsunami or something like up, this a very long period as started propagating and immediately this.

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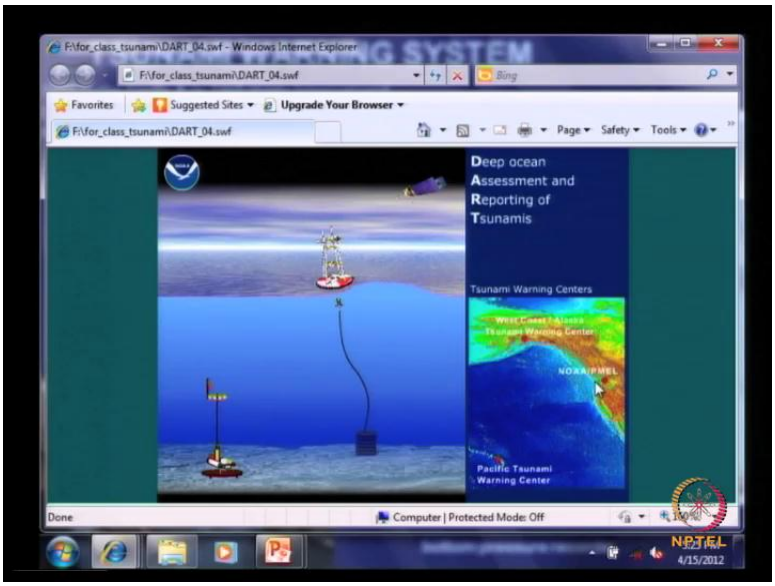


So, this is based on this principle, this dot system works and the so you have the wave rider buoy, you install a bottom pressure recorder and then when there is a shake in the earthquake and then so the signal is sent to the wave rider buoy from which, it goes to the satellite. And from there it sense a warning signal to the on shore station, this is the this is from the pacific tsunami warning center where, we have downloaded the system and our system for the Indian ocean warnings Indian tsunami warning system is also working on the same principle.

And it has been proved that, it works all right so for all the details, you need to go and the check the website and in coil is the organization which is dealing with this.

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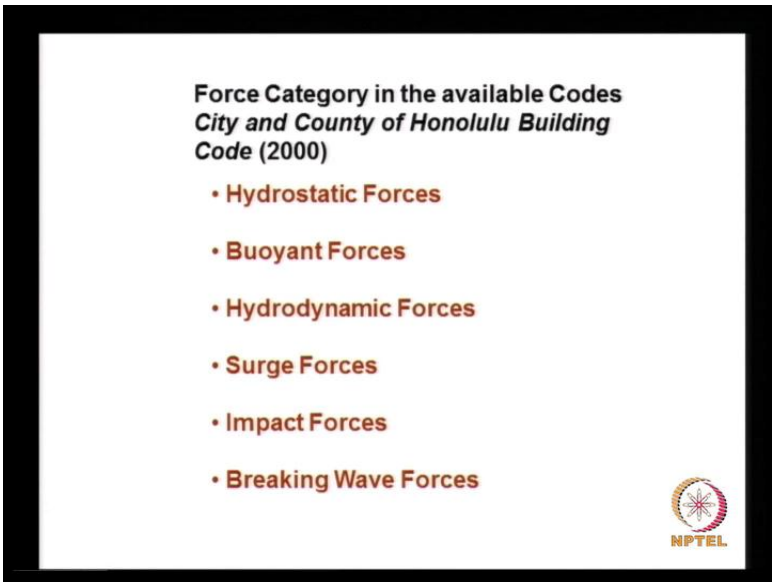


Now, coming back to the forces, force categories available in the available codes city and county of Honolulu building code that is, Honolulu that is in Hawaii, USA. So, what are all the different kinds of forces that can occur during the ingress of a tsunami, hydrostatic force, buoyant force then hydrodynamic, surge forces, impact forces and breaking wave forces.

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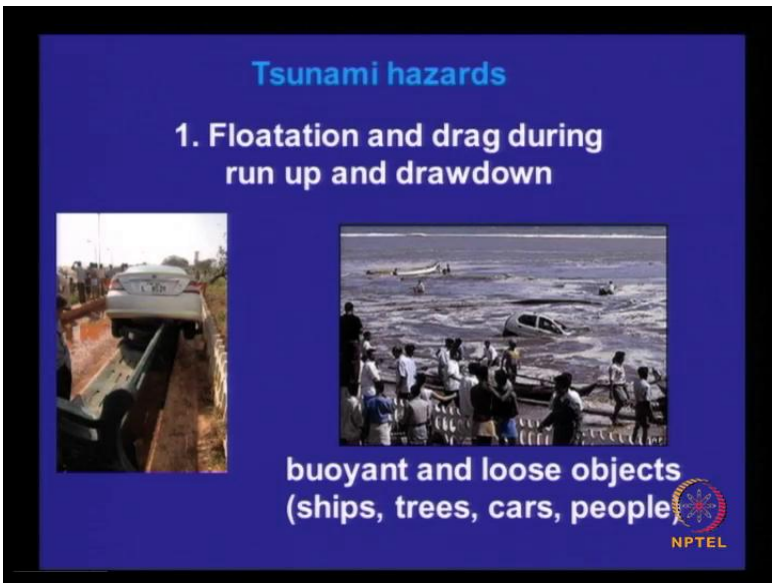


So, along the Indian coast, you see that, there was a floatation drag force due to a run up and draw down buoyant and loose objects like ships, trees, cars and people.

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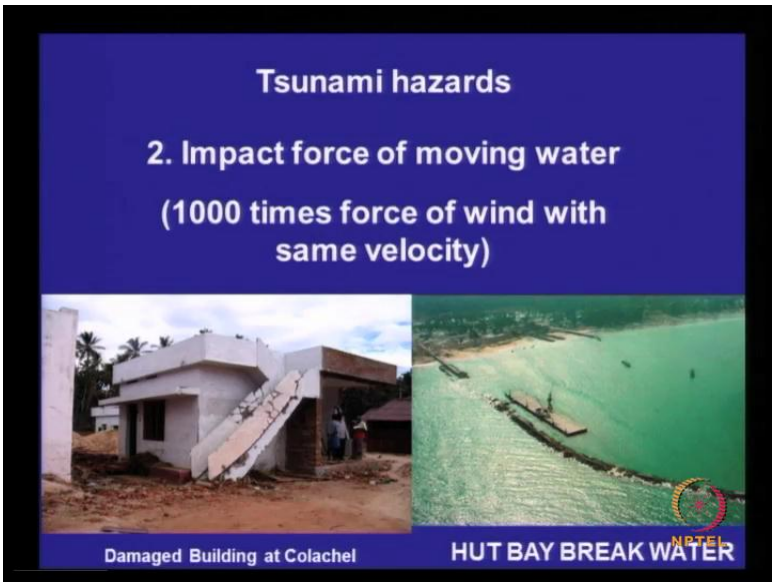


Then, tsunami hazards second is the impact force of moving water so you have thousand times force of wind with the same velocity. So, you look at this, during a tsunami during the tsunami none of the break waters etcetera got affected, not much the damage was not much along the Indian coast along I mean, the Chennai coast that was affected by tsunami. So, but this one was affected, the complete bridge was taken place in Andaman that is because it was this was associated with a earthquake plus the tsunami, and that is the reason why you have.

Because, when you have a movement of tsunami, it is only the static built up of the water, which can really sustain but if it is but if it moving in the other, if you have an obstruction in normal to the direction of the wave propagation, normal to the propagation of the tsunami then the whole building will collapse, you understand.

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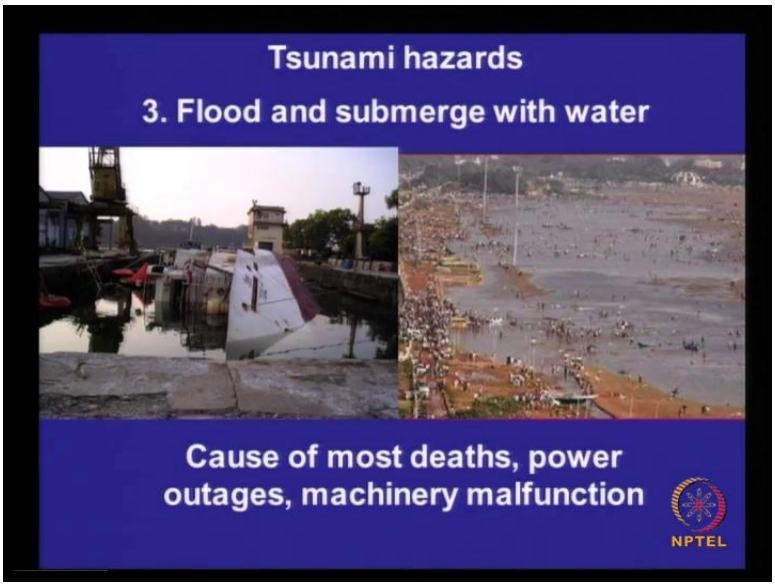


This is flood submerged with water, submergence cause of a because of, so much of water, the sea water entered the buildings etcetera, where you have building or industries factories etcetera. So, you had the short circuit taking place and then because of that, a lot of people died because of, this problem.

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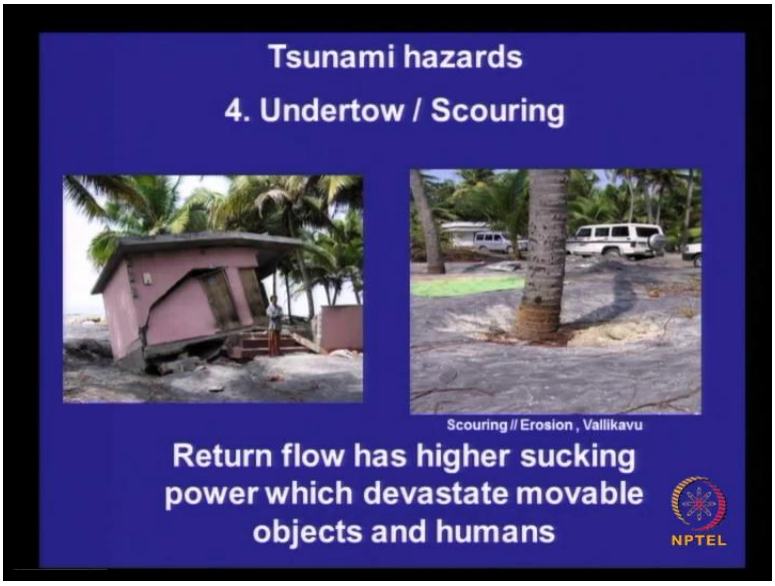


Then the tsunami under toe and scouring as you can see here look at the devastation effect of this building. The whole thing is toppled and you see the retaining water makes

scour, this is only an example, there are several buildings which suffered scour and ultimately collapsed.

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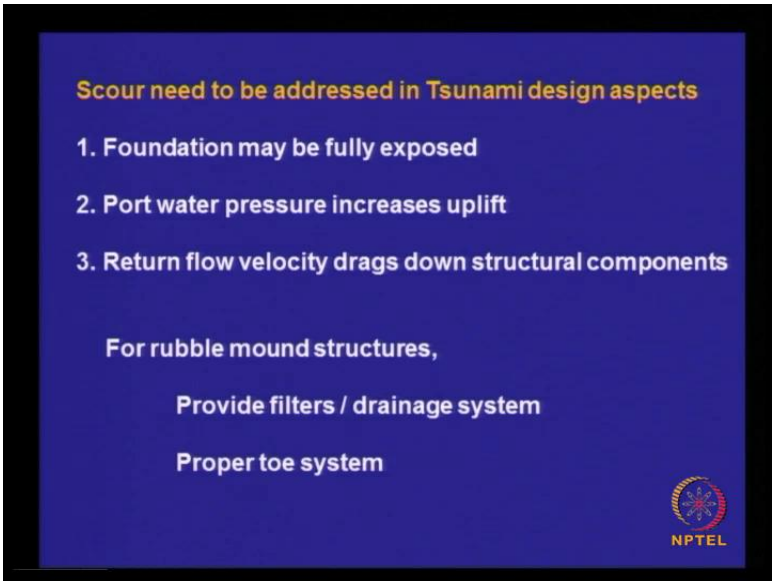


Scour need to be addressed in tsunami design aspects, foundation may be fully exposed, pore water pressure can increases increases up uplift, that is another problem. Return flow velocity drags down structural components, these are the effects due to the scour taking place. For mound rubble mound structures, you may need to provide a filters, drainage systems and proper toe systems.

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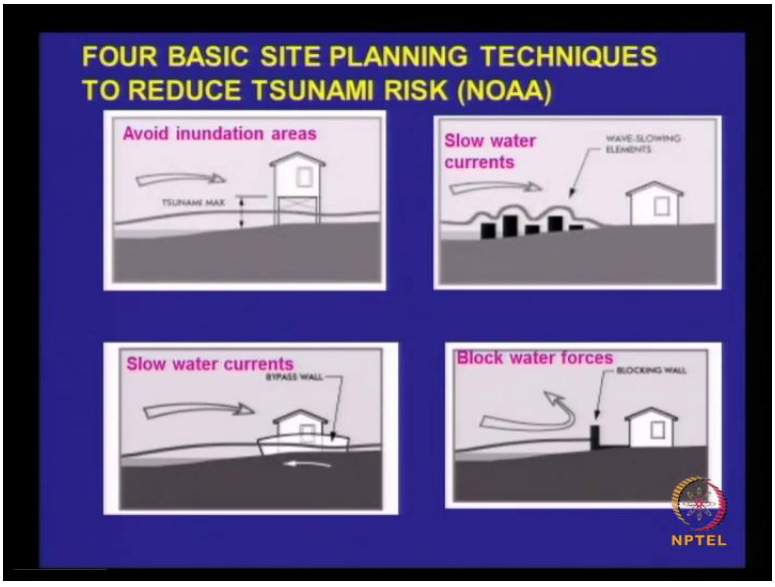

Which we have already discussed in some of the lecture earlier lecture then 4 basic site planning techniques to reduce a tsunami risk that is, as per NOAA that is, avoid inundating inundation areas. So, that is one area but if it like this, you have the structures only on piles, do not have any obstruction, solid obstruction. If you have solid obstruction, you are in for trouble or you have a buffers as shown here, some elements so that, it will reduce the run up.

And also, you can stream line your structure like stream line, which is quite expensive also or you can have a block walls as shown here, like corn walls in the case of, break waters. So, some of this aspects are, you just have on piles as I have said earlier so that will reduce the forces, this is tsunami proof housing wherein, you see that, it is supported on piles.

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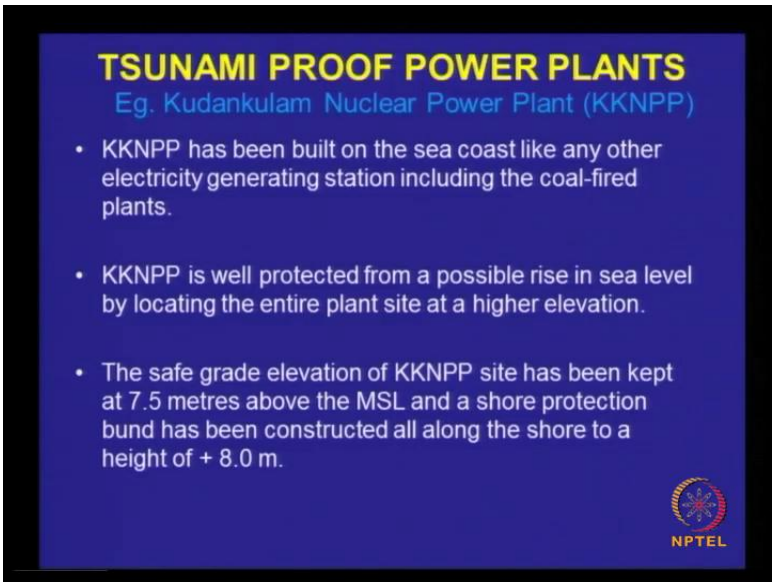


Tsunami proof power plants example, the Kudankulam nuclear power plant, which was being discussed for several for several weeks or months and the... So, this has been, I am just touching only from the technical point of view and I am not I have not done any work on this, just whatever has appeared in the public domain I am just sharing with you. So, this has been built on the sea coast like any other electricity generating station including the coal fired plants.

It is well protected from a possible rise in the sea level by locating the entire plant site at an at a higher elevation. The save grade elevation of this KKNPP site has been kept at

7.5 meters above MSL and a shore protection bund has been constructed along the shore to a height of about plus 8 meters.

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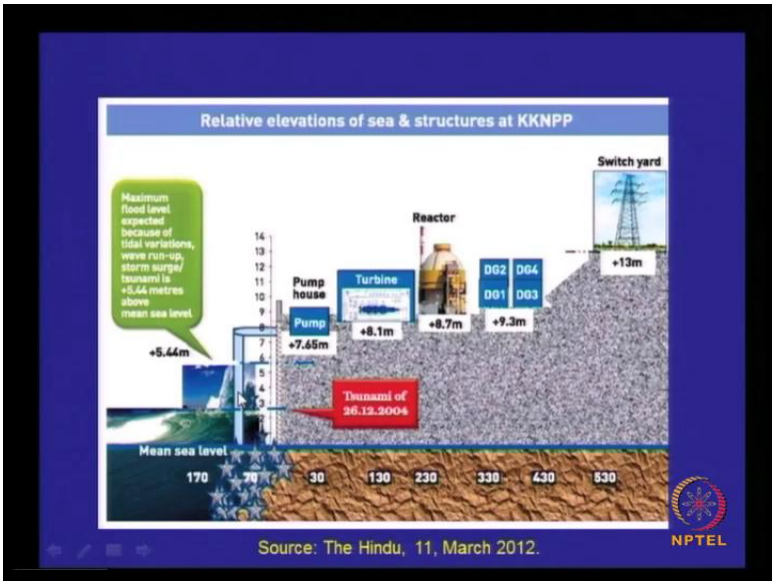


So, this is the view that has appeared in the Hindu wherein, this is the, let us not go into the complete details now, this is the reactor point with the level of, which is plus 8.7, the level of the pump house is plus 7.65, tsunami of 26th that is, the worst occurrence. That is, that could be treated as 1000 year flood level, tsunami level is treated as 1000 year flood level. So, that is coming only here, so still you have such so much of buffer, so absolutely safe, there is no problem.

So, reduction of tsunami flow velocity you can decrease by having like this or by green belt. As we have already seen, this is this is the view of having green belt but the density is not much probably, they are still planning it.

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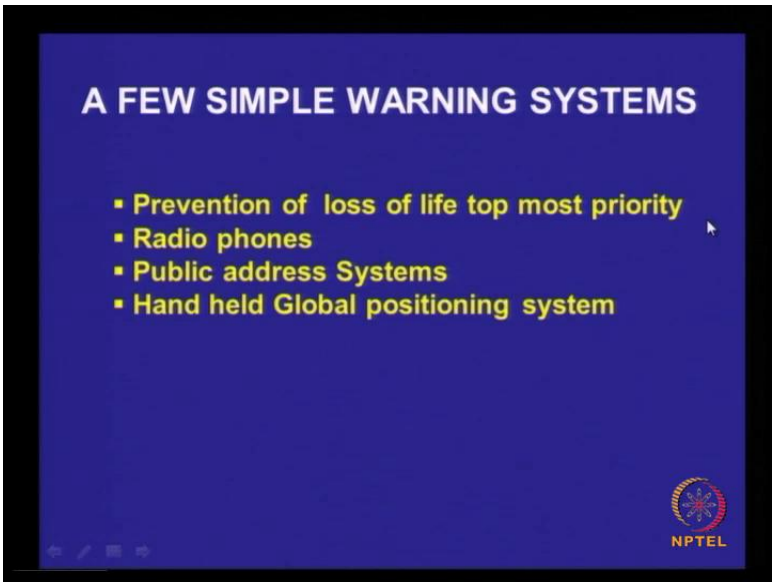


So, they use prevention of loss of life the topmost priority then radio phones, public address systems, hand held GPS all these things can be used.

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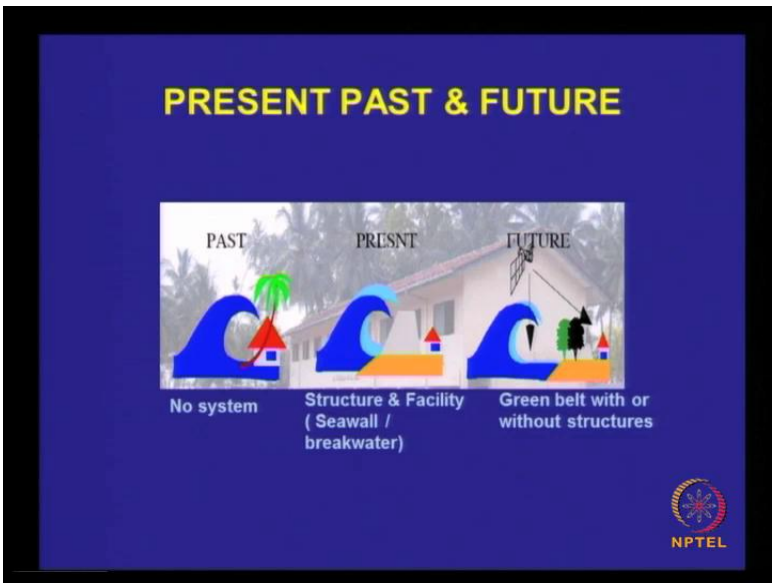


Then, no system in the past, present structure and facility sea wall and break waters, we resort to only this structural measures. Now, the future should be green green belt with or without structures, that is the reason why I showed also the studies research studies on the green belt.

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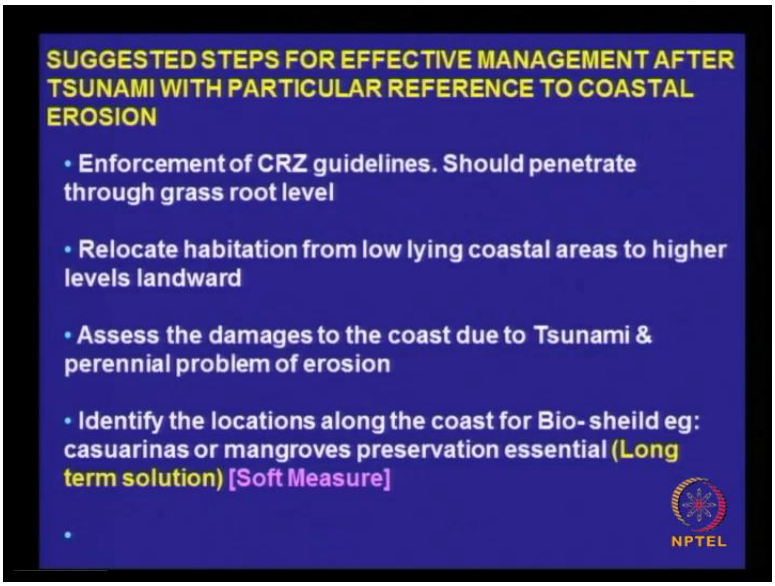


So, suggested steps suggested steps for the effective management after tsunami with particular reference to coastal erosion, enforcement of CRZ guidelines. CRZ guidelines is nothing but the coastal regulation zone so this there are some guidelines, which we have to adhere to should penetrate through the grass root level. So, everyone should know what is CRZ, so relocate habitation from low lying coastal areas to high level higher level landward.

Assess the damages to the coast due to tsunami and perennial problem of erosion, and identify the location around the coast for bio-shields example for example, you can think of a casuarinas or mangroves, preservation mangroves preservation is very important and this can be a long term solution.

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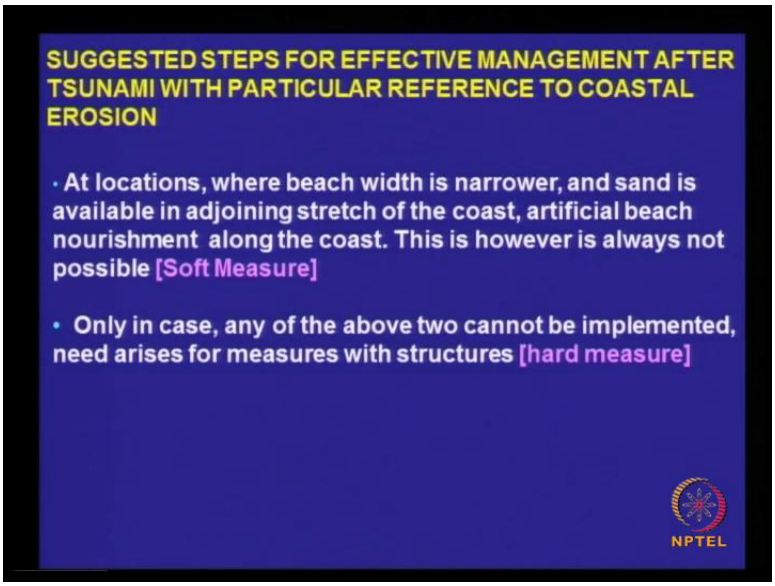


And it can also be called as and is also a software soft measure, at locations where, beach width is narrower and the sand available in adjoining coast, stretch of the coast, artificial nourishment along the coast. This is however, always not possible but it could be thought of, only in case or any of the above two methods above two that is either the plantation or the artificial beach nourishment, is not possible we should really think of structural measures. Because structural measures we have enough knowledge, we can do the structural measure but try to have the structural measures to as a last priority.

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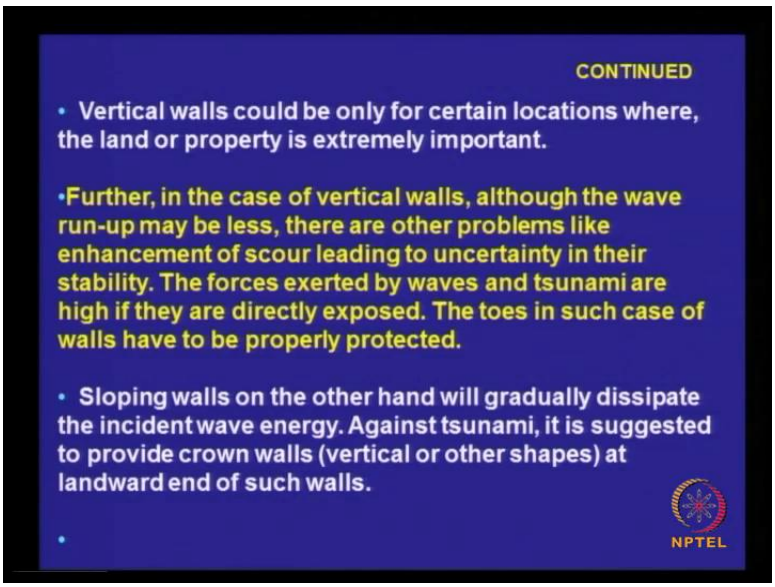

Vertical walls should be constructed only at locations where, the land or property is extremely important further, in case of vertical walls, although the wave run up may be less, there are problems like enhancement scour, leading to uncertainty in it's stability. The forces exerted by waves and tsunami are high, if they are directly exposed to then the toes toes of such structures has to be properly protect, has to be properly designed and executed.

Sloping walls on the other hand, will gradually dissipate the energy that should be the criteria, against tsunami it is suggested to provide crown walls, a vertical shape or other shapes, as we have discussed earlier in one of the lectures.

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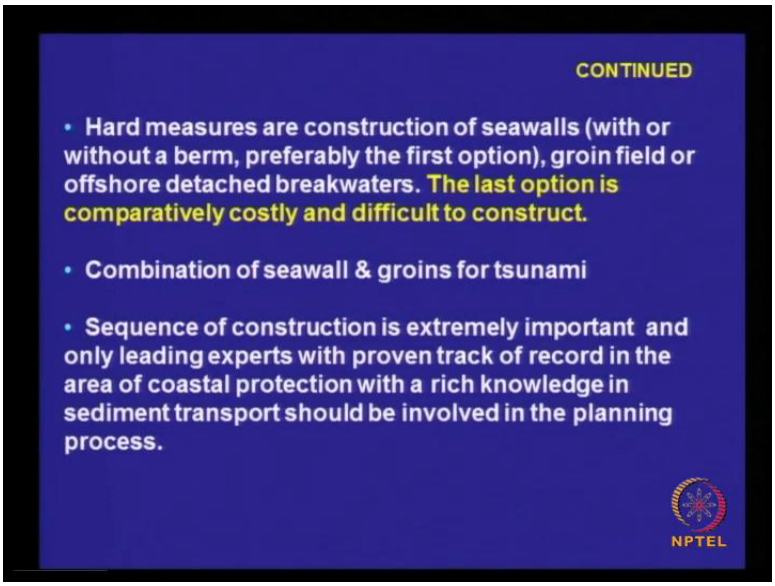


Hard measures are construction of seawalls with or without berm, preferably the first often option groin field or offshore breaker break waters. The last option is comparatively costly and difficult to construct that is, the off shore break water but now, I have earlier said that, off shore detach break water with energy converters can be one possible viable proposition wherein, you can it can serve as a coastal protection as well as for extraction of wave energy, combination of a sea wall and groins for tsunami. And then finally, the sequence of construction is extremely important, when you are planning for a coastal protection measure.

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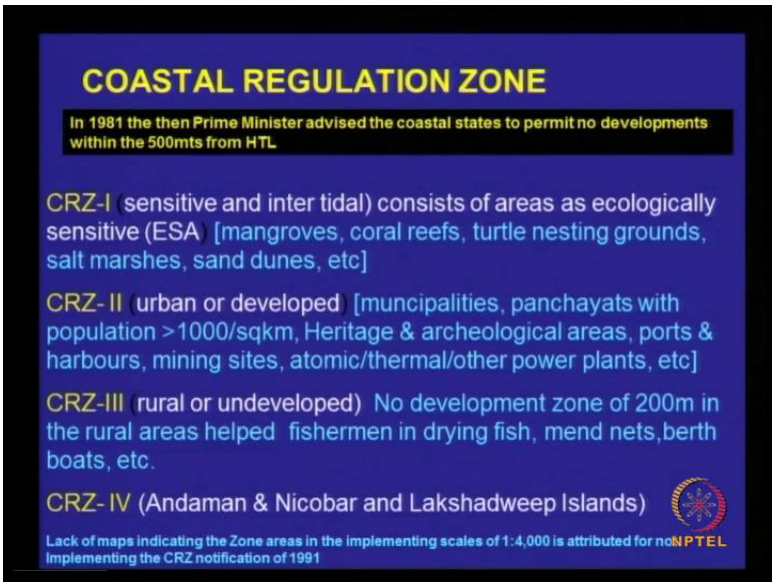


So, CRZ coastal regulation zone, I suggest you check the net for just put a coastal CRZ, this itself will take you to all the details. There are basically 4 zone CRZ 1 sensitive and inter tidal consisting of areas as ecologically a sensitive that is, ESA. So, that is a zone stretches of the coast where, mangroves, coral reefs, turtle nesting grounds, etcetera, these are all coming under CRZ 1 GR.

CRZ 2 urban or developed municipalities, panchayats, etcetera with population greater than 1000 per square kilometer, heritage archeological areas, ports, harbors, mining sites, atomic power plants, etcetera all these things come under CRZ 2. CRZ 3 is rural undeveloped, no development zone of 200 meters in the rural areas, will help a fisher man for drying their nets fish, etcetera.

So, and then finally, for islands they have a CRZ 4 so actually according to this, it was in 81 then prime minister Indira Gandhi has advice the coastal states to permit no development within 500 meters, from high tide line. But not many many times states really followed this, if you see you can see so much of development that has taken place within that 500 meters from the high tide line.

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So, I would like to take some time, in acknowledging all the people, I have liberally taken from NGRI. Some of the slides NOAA, NRSA, survey of India, Hindu, several websites, USGS, colleagues, friends and students.