Engineering Geology
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Lecture - 34
Geologic Hazards - Shoreline Processes

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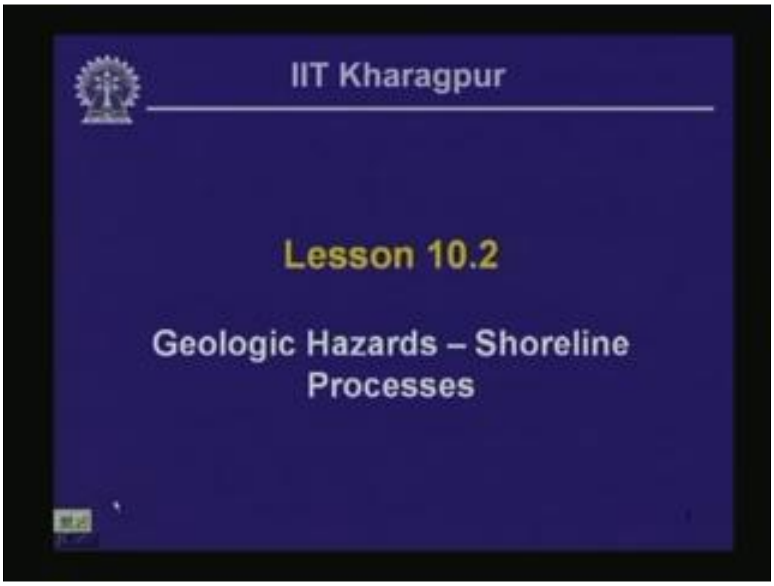

Hello everyone and welcome back today we are going to talk about a new kind of geologic hazard that arises, because of different shoreline processes such as wave action or tsunami waves, but before we go ahead with the today's lesson, let us look back at the question set of the previous lesson.

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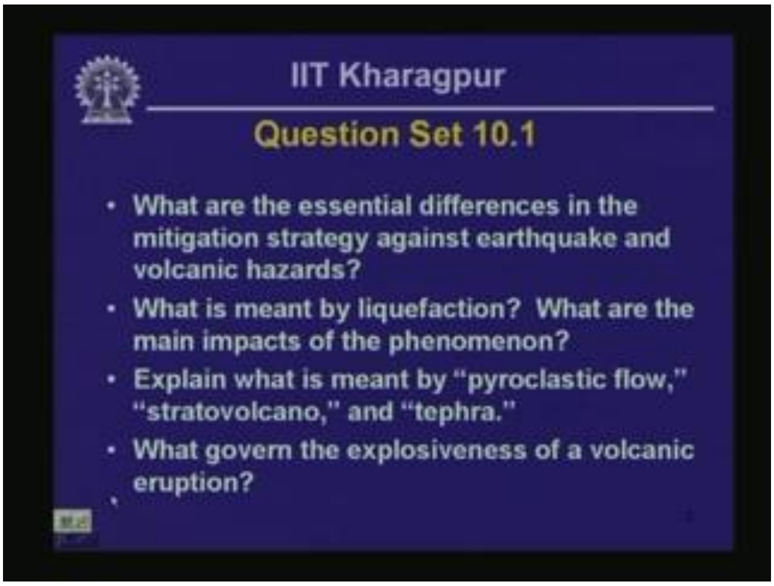

Here are the questions. The first one that I asked was what are the essential differences in the mitigation strategy against earthquake and volcanic hazards? Now if you recall what became apparent from the discussion that we were having in the previous lessons is that the process of earthquakes cannot be predicted. On the other hand, in many cases the likelihood or the timing of volcanic eruption to some extent can be predicted.

So, the mitigation of earthquake hazard is basically done by managing the risk involved depending on the statistics of the past earthquakes recorded in a given region. On the other hand, volcanic hazard to a great extent is managed by predicting the timing of a volcanic eruption and removing people from the areas that are likely to be affected by different kinds of volcanic hazards. So, this is basically the main difference between the mitigation strategies associated against earthquake and volcanic hazards

The second question that I asked was what is meant by liquefaction, and what are the main impacts of the phenomenon? Now liquefaction is primarily a phenomenon associated with elevation of pore water pressure within the matrix of relatively coarse grain soils which derive most of their strength from frictional interaction between different individual particles that compose the media. Now because of pore water pressure increase, the grain to grain contact force measured by the effective stress is largely reduced.

And in the extreme case when the elevated level of pore water pressure becomes equal to the initial total stress, then the effective stress becomes zero. In that case, the coarse grain soils start behaving like a thick viscous fluid, and this particular phenomenon is called liquefaction. Now you can realize that since this type of soil derives most of the shear strength from inter particle because of the stress that develops at the contacts between individual particles when liquefaction occurs, the shear strength also drastically decreases.

And as a result, if there is a little slope at the base of the liquefied deposit, then the deposit on top of it is going to flow in the down slope direction. And this leads to the so called phenomena of landslides as well as lateral spreading which we illustrated with a photograph in the last lesson. Also because of liquefaction if the pore water pressure develops at some depth below the ground surface, the elevated level of pore water pressure starts to it actually mobilizes the ground water flow, and the flow takes place upward in many situations.

And that upward flow mobilizes individual soil particles, and those soil particles are carried to the surface in the form of the sand craters. And because of the ejection of sand from some depth underneath the ground surface, uneven settlement takes place within the affected area. These are the salient impacts of the phenomenon of the liquefaction. Now the third question that I gave was for you to explain a few terms associated with volcanism. And he first one was pyroclastic flow, the second one stratovolcano, and the third one that I asked was tephra.

Now pyroclastic, what is meant by pyroclastic flow? You think about a volcano where the activity is because of highly viscous magma. And in that case, you know that the volcano is going to behave in an explosive the eruption is going to be rather of an explosive nature. And that explosion is going to eject pyroclastic material, rock fragments, hot gases, a mixture of those, it is going to get ejected several hundred meter vertically upward.

And after ejection, this particular material which is as I mentioned a mixture of hot gases and rock fragments, they are going to settle; they are going to fall downward and settle on the ground surface. And this particular mixture of hot gases and rock fragments is highly mobile, and if it settles at a location where there is valley like features in the topography, then they are going to flow downward along the valley to some distance. This particular phenomenon is known as pyroclastic flow.

Then the second term that I asked you to explain was stratovolcano. These are basically volcanoes of explosive nature in which you have got alternate layers of lava flow and tephra deposit. And because of the resistance against erosion of the lava flow, these features can grow to a great height. And some of the most majestic volcanoes across the world are of this category. Among them is Mount Fuji of Japan and Mount St. Helens, the volcanic hazard of which we discussed in the previous lesson.

And the third term that I asked you to explain was tephra. Tephra is, in fact, is a mixture of pyroclastic material composed of different sizes of rock fragments covering a large spectrum of grain sizes. The fourth question was what governs the explosiveness of a volcanic eruption. This question I answered already in one of the previous questions of this question set. Explosiveness is partially governed by the viscosity of the magma; that means if the magma is more viscous, the volcano is likely to behave in an explosive manner or the eruption is going to be explosive.

And since silica content of the magma governs the explosiveness. So, with increasing silica content actually since silica content governs viscosity. So, with increasing silica content, the explosiveness also is going to increase. On the one hand, you have got low silica content, basaltic magma. These tend to be non-explosive. The volcanic activity associated with that kind of magma is typically non-explosive, whereas andesitic magma which has got a larger proportion of silica, it is going to likely to give rise to more explosive eruption.

The second aspect that actually governs the explosiveness is whether water is available near the eruption site. If water can come in contact with the magma or with the magma as is getting ejected, then that increases the likelihood of an explosive eruption. So, these are the factors basically that govern whether a volcano is going to behave in an explosive manner or not. So, that takes care of the question set.

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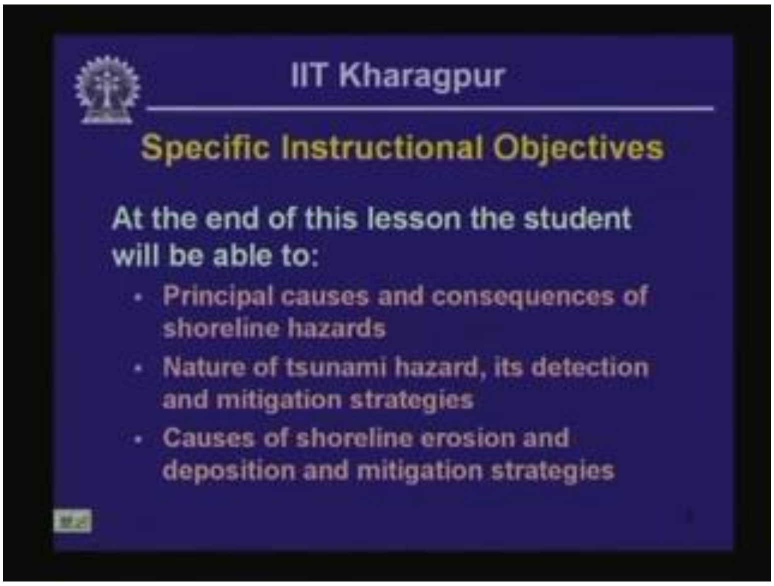

And now we move on with today's lesson. The objectives of today's lesson are as follows. We are going to look at the principal causes and consequences of shoreline hazards. We are going to look at the nature of tsunami hazard, its detection and mitigation strategies. And we are also going to look at the causes of shoreline erosion and deposition and mitigation strategies that are normally employed to control these processes.

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So, first of all what comes to mind are what are the causes of shoreline hazards? Shoreline hazards are primarily due to the wave action, and the wave action could be normal wave action; wave action that is because of the normal water level or the waves could be more significant such as those that arise during storm events. Then there could be swelling of water level, and that can be due to low pressure system associated with large storm systems and cyclones or tsunami, which can be triggered because of an earthquake or because of an underwater landslide or underwater volcanic eruption or even because of an impact of a very large meteorite on the surface of the water body.

Then what are the consequences of these actions? One of the recent events that come to mind in this respect was the destruction of life and property caused by the December 26th, 2004, tsunami. In this context at this time, I want to mention that in the previous lesson when I was talking about the relative impacts of different types of geologic hazards towards the beginning of the lesson. I was showing a graph, and while explaining the graph, I gave the date; I gave a wrong date for this particular tsunami. I was saying that the date was January 26th, 2004. In fact, it is December 26th, 2004.

So, you should take a note of that and make the necessary corrections in the notes that you might have developed for your own use. Now coming back to this particular event, the consequences are best explained perhaps by the tsunami event of December 26th, 2004. And the number of deaths caused by this particular event was as large as 240000 across several countries in Asia and Africa, and India was also one of those countries largely affected by this particular event.

So, this caused a wide spread destruction of life and property in the southern parts of India as well as in the Andaman and Nicobar island chain. Then the second consequence and this is perhaps less dramatic, but this is perhaps more wide spread in comparison with the stark destruction of life and property associated with relatively in frequent events such as tsunami is erosion and reshaping of coastlines. Because of erosion, large tracks of land are regularly lost because of shoreline erosion; large tracks of land are regularly lost, and because of deposition, navigation of important water waves is routinely affected.

So, we are going to develop some strategies or we are going to look at the essential features of the mitigation strategies that are identified by engineering geologists and geotechnical engineers to correct to manage the hazards associated with these aspects, okay.

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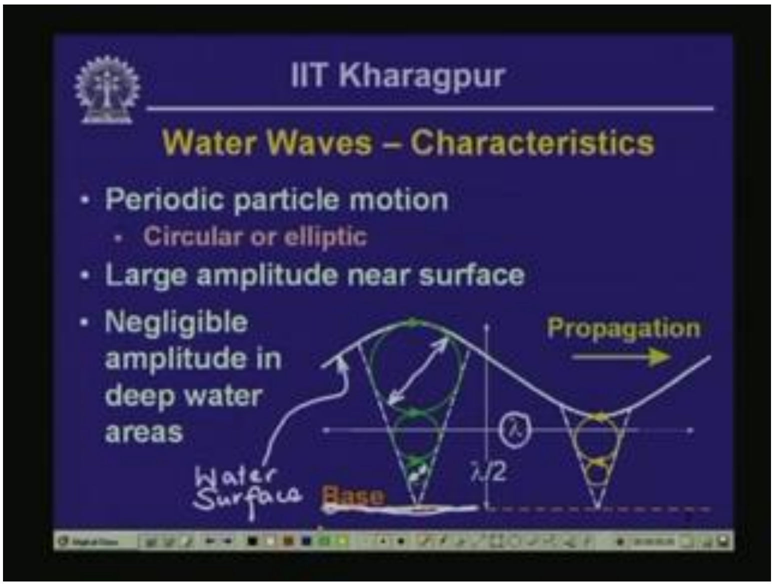

Now to begin with, we want to look at we want to take very quick look at the nature of water waves because this is the major agent involved in the different kinds of shoreline hazard. What is a water wave? Water wave is essentially a periodic motion of water particles in which the particles move in a circular or an elliptic pattern. And this particular motion actually leads to the generation of an undulation on the surface of the water basically, and this undulation is of periodic nature as is indicated on the bottom right sketch in this particular slide.

And what you see here is that the amplitude of the particle motion, it is the largest near the surface of the water. This is the water surface here; this one here is the water surface. So, what you can see here is that the amplitude of particle motion is the largest near the surface, whereas as the depth increases, it becomes smaller and smaller. And when approximately you reach a depth of about half of the wavelength, wavelength is indicated here in this particular sketch using the symbol lambda, which is the distance between two points on the surface of the water where the periodic motion of the particle is in the same phase.

So, if you reach a depth of about lambda over two from the surface of the water, then you are going to reach a point where the particle motion becomes negligible; the amplitude of the particle motion becomes negligible, and that occurs at a depth at a location which is called the base of the wave. So, what is obvious from this particular sketch is that below the base of the wave, you do not have any significant particle motion associated with this type of wave.

Now this periodic motion actually this periodic disturbance, it propagates in a certain direction, and because of the propagation of this wave, it carries energy from one point to the other within the body of the water. For instance in case of tsunami, the energy that is generated at the seafloor because of the rupture of a shallow fault because of an earthquake or because of volcanic activity; that energy is carried with the wave that the earthquake or underwater volcanism generates to great distances.

Now what happens in this particular case is that the energy as in case of other waves that propagates in radially away from the location where the waves were generated because of some disturbance at the water surface, this energy actually dies out. But the speed or the ease with which the energy dies out or decays depends on the wavelength of the wave. If the water wave is a short wavelength wave; that means lambda is relatively small, then the energy is going to die out relatively rapidly. On the other hand, if you have got a longer wavelength associated with the water wave, then the energy is not going to die out that easily. And the energy is going to be carried to great distances away from the location where the wave was originally generated, okay.

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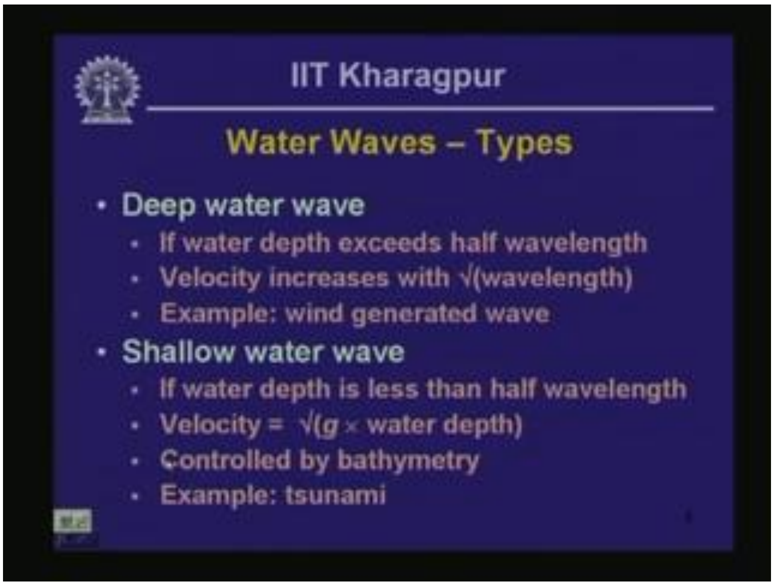

Now what are the types of water waves in way the water waves are classified is what is the water depth in comparison with the wavelength of the water wave? So, if the water depth exceeds half wavelength, then the water wave is called a deep water wave, and in this particular situation, velocity increases with square root of wavelength. So, a wave that has got a longer wavelength, it is going to faster in this particular case. Example of this class of wave is wind generated wave such as storm waves. Then on the other hand of the spectrum, you have got shallow water wave.

Here the water depth is less than half wavelength. And in this case, velocity of wave propagation does not depend on the wavelength, but it simply is a function of the water depth as is indicated with this particular equation. So, it is velocity in this case is simply equal to square root of the acceleration due to gravity denoted by symbol g multiplied by water depth. So, it is obvious then the propagation of this type of wave is controlled basically by bathymetry. And if you recall, the term bathymetry means the profile means it is very similar actually it is analogous to the term topography.

But here topography is used to denote the surface features, but bathymetry is used to denote the features at the bottom of a water body. So, bathymetry also is expressed or graphically shown using contours, and they are called bathymetric contours where the contour level denotes the water depth at the location of the contour. We are going to look at that in the next little bit. So, propagation of shallow water wave is controlled by bathymetry.

An example of shallow water wave is tsunami, because in this case, the wavelength is on the order of hundreds of kilometers. So, even in Deep Ocean, the water depth is not enough for the tsunami wave to be classified or categorized as deep water wave. So, even in Deep Ocean, they are of the type of the classification of shallow water wave, okay.

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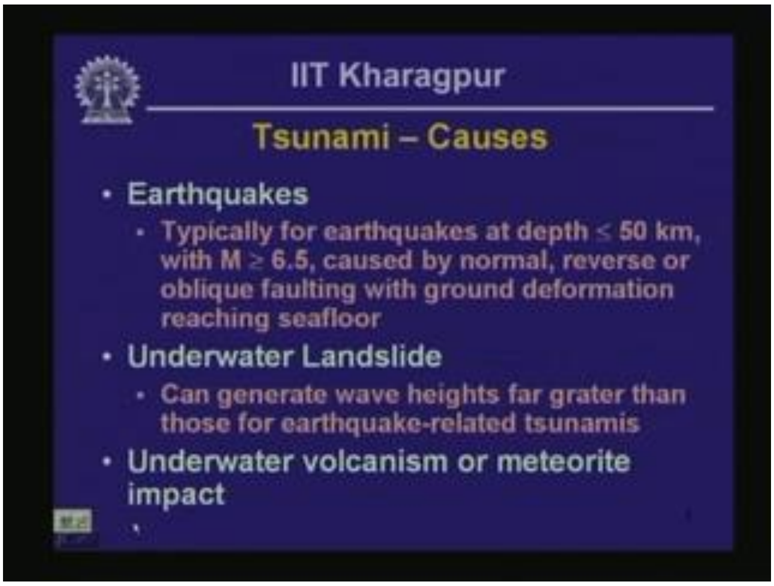

Now we look at we have studied this one already to some extent, but we look at formally what are the causes of tsunami. In the first part of this particular lesson, we are going to look at the effects of tsunami and how the hazards due to tsunami is managed or the risk due to tsunami waves is managed. As is shown here tsunami can be caused by underwater earthquakes. In this case, typically earthquakes need to be shallow events that occur at the depth of less than fifty kilometer from the ocean floor. And it is also required that the magnitude of the earthquake is greater or greater than or equal to about 6.5.

Typically, the tsunami waves are generated by normal reverse or oblique fault wreck with ground deformation reaching seafloor. You need to have a disturbance caused right at the seafloor in order for the tsunami wave to generate. Underwater landslide can also give rise to disturbance at the seafloor; this also gives rise to tsunami waves. And, in fact, the tsunami waves that are generated by underwater landslides are more hazardous than the typical earthquake related tsunami waves, because underwater landslides can be more often than not near site or the disturbance can be very close to the location where the wave is causing the damage.

And secondly, the wave height that is associated with water waves due to underwater landslides could be much larger in comparison with the wave heights that are associated with earthquake related tsunami events. In fact, one of the largest wave heights postulated by engineering geologist or geologist rather was because of the tsunami event in a location called Lituya Bay in Alaska in western north in the United States. And what the geologist inferred there depending based on denudation of the forest cover or height of the locations up to which the forest cover has been destroyed by the tsunami wave. And they, in fact, inferred the tsunami wave height for that particular event was a few hundred meters. And that is one of the largest wave height ever postulated of any water related waves. Then underwater volcanism or meteorite impact on the water surface could also be two more reasons of generation of tsunami, okay.

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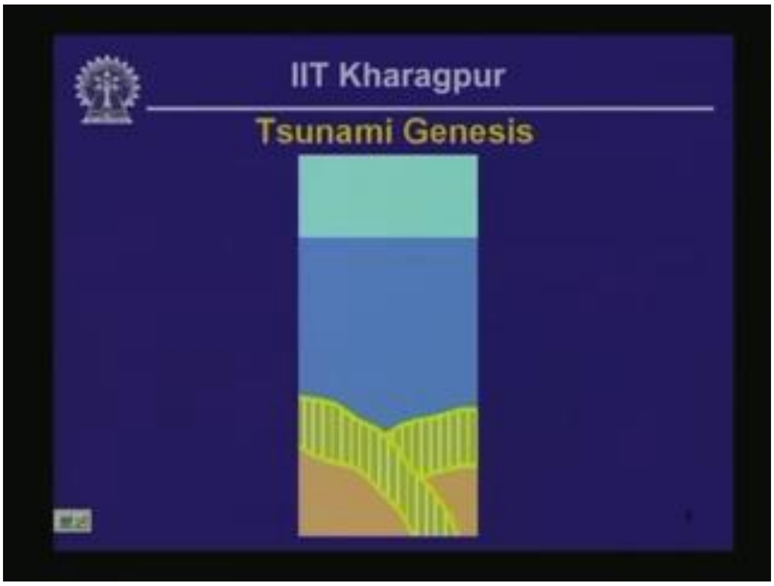

Now here in this particular slide, we have got a got an animation that shows how tsunami wave is generated. Now you should notice what we have got at the floor of the ocean itself floor of the sea itself is a couple of plates. It is a schematic that I used to show basically a converging boundary, where the tectonic plate to your left actually is subducting underneath the tectonic plate on your right. And the green cross hatched layer at the ocean floor that represents the oceanic crust, whereas the brown unit at greater depth denotes the asthenosphere which you recall from previous lessons on seismic activities.

Now you should notice that the sliding down of the subducting plate has dragged downward the plate that is on your right, and because of this dragging down, what has happened? A four arc valley has formed at the contact at the ocean floor. Now what happens? This type of dragging down typically is caused by the interlocking between the subducting plate and the plate that is overriding the subducting plate or under which the subducting plate is moving downwards, and because of the frictional interlocking of the plates, the plate on your right gets dragged down.

Now this increases the stress within the rock in the vicinity of the locked up zone, and when this elevated level of stress cannot be sustained by the crust rock mass, then there will be a rebound. And the plate that is on your right, it is going to rebound upward as you will see in the next little bit in the first part of this particular animation. So, I start the animation now; you just watch it closely.

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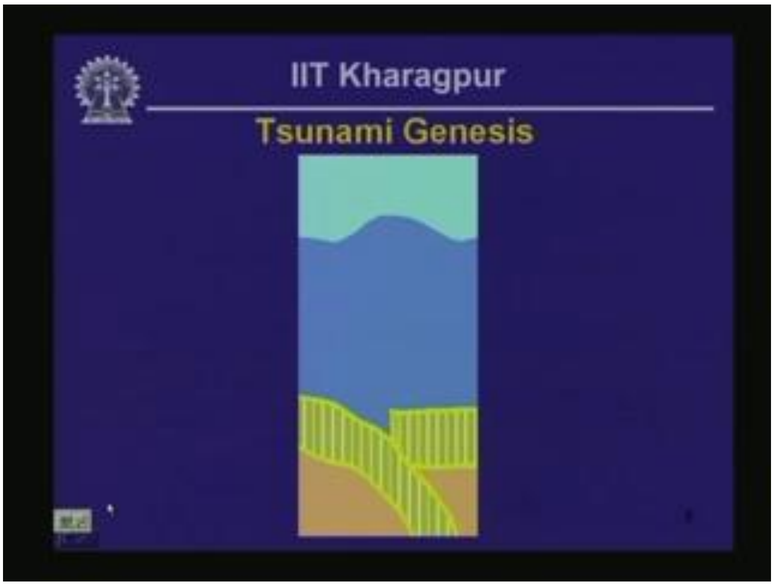

So, it goes like this.

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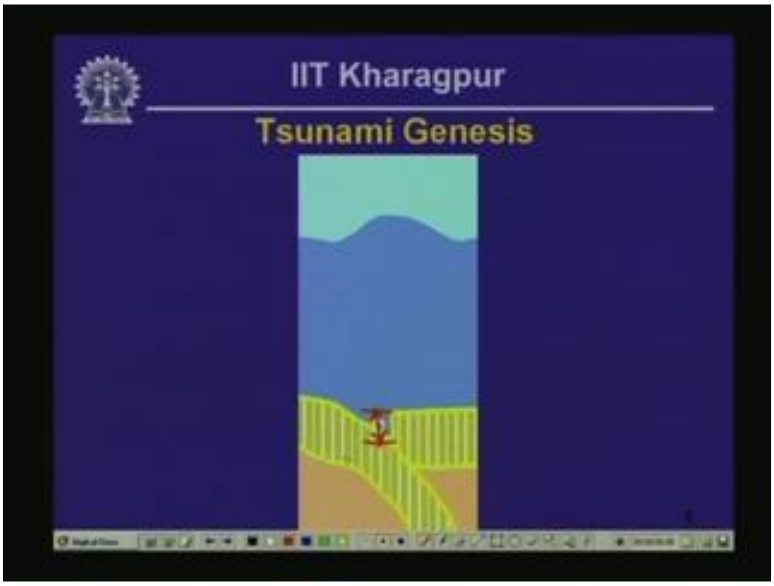

And you can see because of the rebound where now the crust on the plate to your right has moved upward by that much of amount or the upward movement in this case is of that amplitude. This particular upward movement is going to push the water column upward, and a wave is going to generate because of this type of movement. Now such movement is not confined within a narrow zone; it could be confined over a rather wide region.

And depending on what is the geometry or the foot print of the sea floor disturbance, the extent of water which is affected or the lateral extent of water which is going to get lifted upward is going to vary. And this is the factor that affects the wavelength associated; this is one of the factors that actually controls the wavelength associated with the water wave generated because of such crustal movements, okay. So, let me run through this particular animation once again. So, you just watch how the crust rebounds and water wave gets generated.

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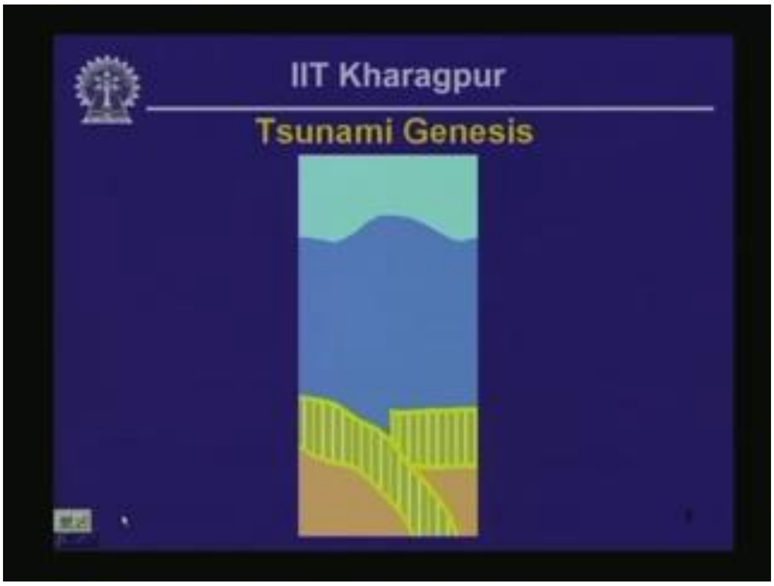

Now we are going to move on this is how the tsunami wave is going to generate and then we are going to move on; this particular wave is going to move away as is indicated on the animation there. So, water wave was like this, and after the water wave is generated just like any other periodic wave, the water wave is going to move away carrying the energy released because of the crustal movement away with it, okay.

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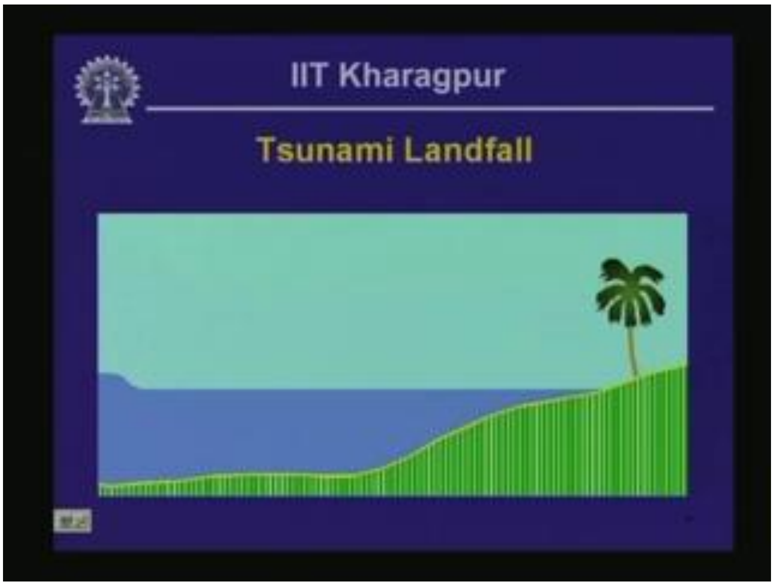

So, this wave is going to start propagating outward, and finally, the wave is going to reach a shoreline. And this one this slide on this slide, we are going to show schematically we are going to see schematically, what is going to happen as a tsunami wave approaches a coast line. So, here you can see that the wave is starting to appear at the left end of this particular animation or this particular sketch.

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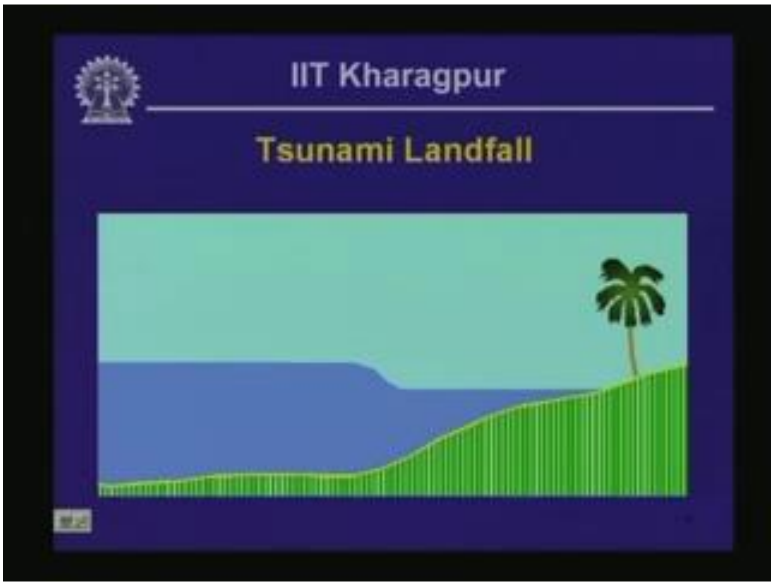

And the progress of the wave, you just follow the progress of the wave and it occurs like this.

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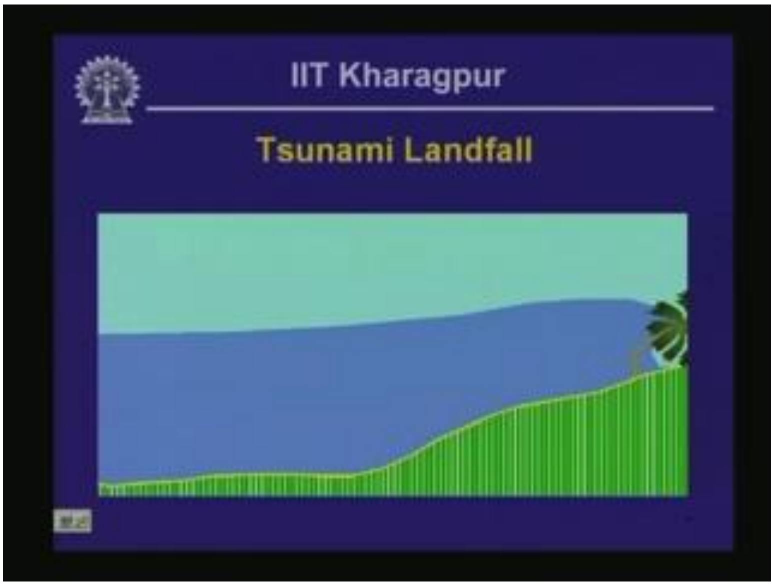

So, this is one of those typical waves associated with wind in which you see a number of breakers, where on the other hand in this particular case, we have got sort of like a wall of water that approaches a high wall of water that approaches the shoreline. Just for your benefit, I am going to run this once again. You just watch the approach of the wall of water so called wall of water in this case.

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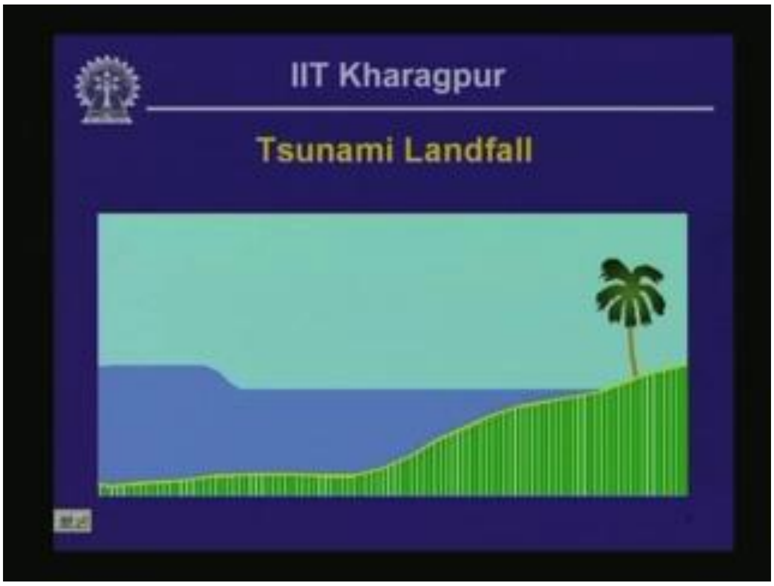

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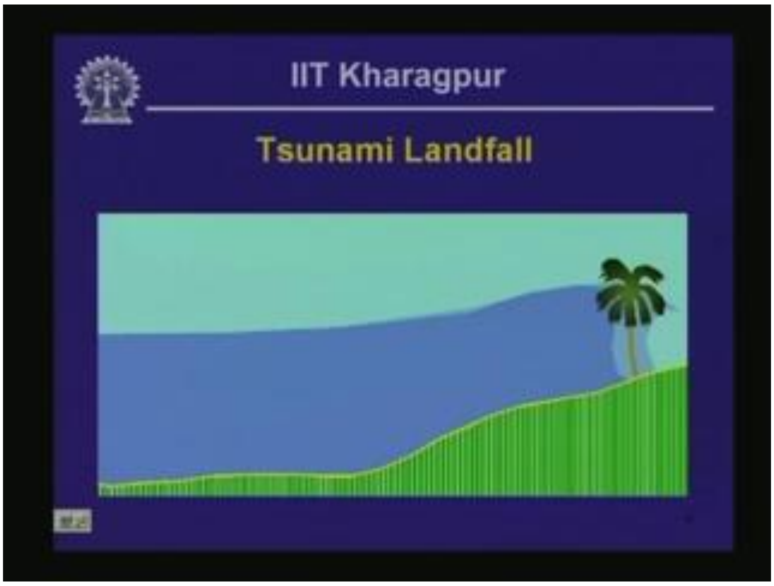

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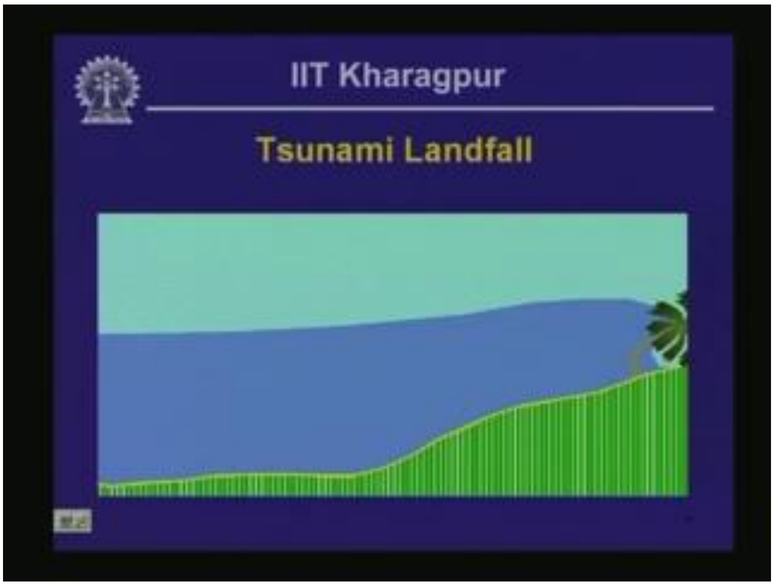

And the wall of water approaches, and finally, near the very end depending on the shoreline topography, a breaker could form near and eventually the wave is going to start receding. Now what is important here for you to realize is that the wavelength of this particular wave is, in fact, enormous. And that is the reason why what you are seeing here is a movement that is as if a several storey high wall of water is approaching the shoreline without any breakers.

Now, what you should also see here is that the profile of the water surface is actually it is similar to the profile of the coast line and the near shore bathymetry and the near shore and the profile of the sea floor in the near shore area. But the feature the geometry of the surface of the water wave is actually is a scale down version rather of the profile that you have got near the shoreline, okay. So, what I am trying to say here is that the top of the water has got a profile which is similar, but it is actually a scale down version of the profile of the seafloor profile and the topographic profile near the shore line, alright.

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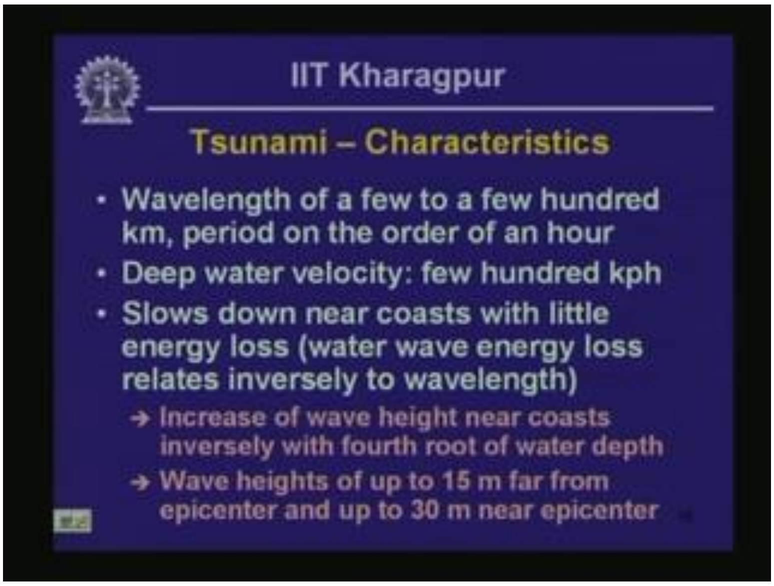

Tsunami characteristics, then from those two simple animations, we have looked at the salient features associated with the tsunami wave. We have got very long wavelengths associated with tsunami waves typically; the wavelength typically is a few hundred kilometers. And period of the wave is on the order of ten minutes to about a couple of hours, and this is important because you should realize that the first arrival of the tsunami wave at a coastal area could be when the wave is at the crest, or the crest is going to arrive the shoreline first, or the trough of the wave could be the first one to arrive the shoreline.

If the trough arrives first then, the seafloor or the sea level is going to recede to a great distance, because you can see the wave height in this particular case would be several tens of meters, in fact; it could be as high as about thirty meters also in case of earthquake related tsunami. So, what is going to happen if the crest or if the trough arrives the shoreline first, then the water is going to recede to a great distance away from the shoreline. And it is going to be just like a low water situation where a large distance of the beach is going to remain exposed.

And in that situation, that is actually a precursor to the arrival, in fact, of the crest of the wave; the crest is going to arrive after May even a couple of hours from the time of arrival of the wave trough. And when the wave crest arrives, it is going to arrive; it is going to appear that a huge wall of water is approaching the shoreline as we have seen in the previous slide. So, in the previous slide we illustrated the first arrival in the form of a wave crest, but you should realize that wave trough could also be the first to hit the shoreline.

In that case, the ocean is going to recede to a great distance from the actual shoreline before coming back in the form of a wall of water associated with the tsunami wave crest. Second thing that is important here is that deep water velocity of tsunami wave could be as large as a few hundred kilometers per hour. Wave propagation velocity could be as large as may be 900 kilometers in very deep waters in this particular case. And the velocity is going to slow down, because if you recall, the propagation velocity of shallow water wave is proportional to square root of g or the acceleration due to gravity multiplied by the depth of water.

So, near the coast, the water velocity is going to slow down. Now since the energy associated with the propagation or the energy does not die down because of the very long wavelength of tsunami waves. So, the energy remains constant. If the velocity then goes down, then you would expect that the kinetic energy goes down as the velocity becomes smaller. So, the water column is going to pile up in order to make up for the loss of kinetic energy.

And in the process, what is going to happen? The wave height is going to increase near the coasts and simple calculations show that basically the wave height increases with the increases actually decreases with the fourth root of water depth as you approach the coast line. And what is normally seen is that wave heights of up to about fifteen meters is possible in at distances of several thousand kilometers away from the location where the wave was originally generated, or the epicenter of the earthquake to a height of up to about thirty meters at locations near the epicenter or the location where the waves were generated. So, these are the typical features are associated with tsunami waves.

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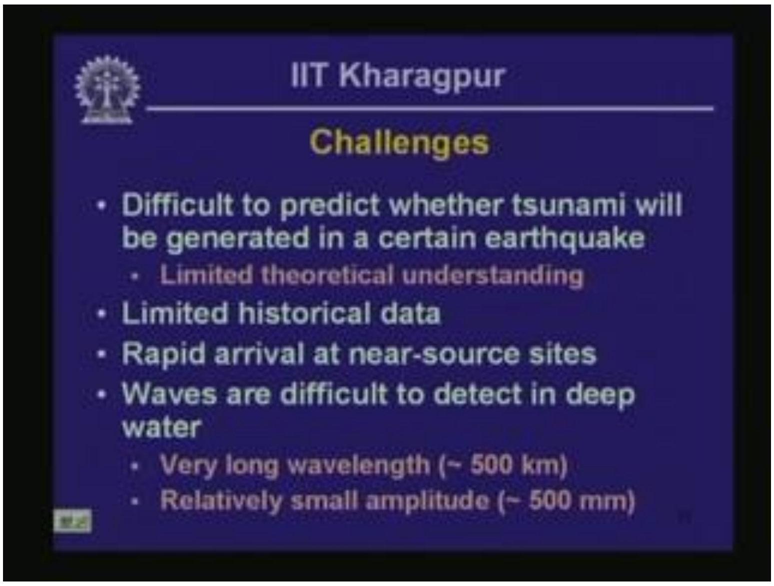

Now in order to mitigate, we have to first see what are the challenges, actually what are the difficulties in order to handle the peculiarities in the characteristics of tsunami waves. The first problem that we have to deal with in this particular case is that tsunami waves are very difficult to predict, because in deep water areas, the waves could be only a couple of feet high with a very, very long wavelength of up to several hundred kilometers.

So, such waves are very difficult to detect. In fact, if you are in a water vessel in a deep water area through which tsunami wave is propagating, you are unlikely to notice the difference due to the wave propagation at all. So, the tsunami waves because of their long wavelength and because of very small wave height in deep water areas, it is very difficult to detect.

Second problem associated with the risk associated with tsunami waves is availability of limited historical data. Third one is rapid arrival to near source sites because in deep water, the waves typically propagate at speeds of several hundred kilometers per hour; it could arrive at near source sites very fast indeed. So, what you have got? You have got very limited time within which you have to evacuate the coastal areas which is often not possible. The fourth problem is as I mentioned the waves are very difficult to detect in deep water because of their long wavelength and relatively small amplitude, okay.

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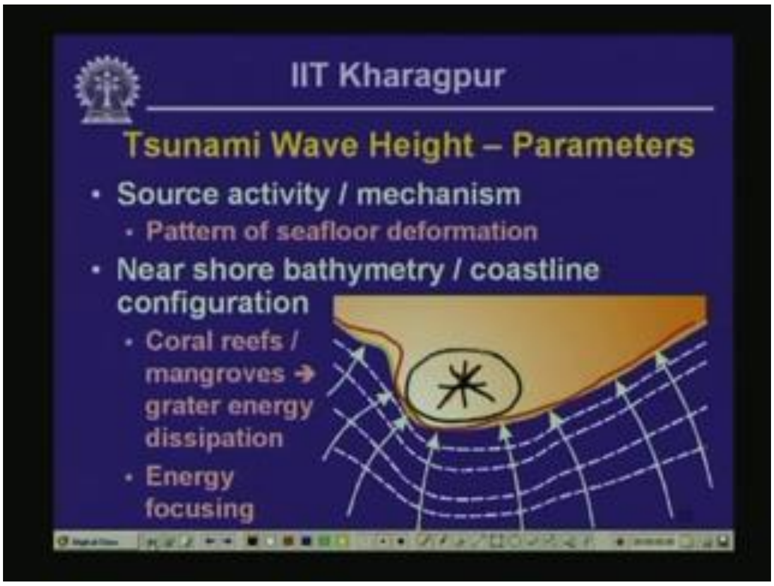

This one now another aspect that requires consideration in order to manage tsunami risk is how high a tsunami wave could be in the coastal area. And if you if you can estimate the height of the wave, then you could evacuate those areas for events that are occurring earthquake events or tsunami generating events that are taking place at a long distance for which adequate warning is available, adequate length of time is available for evacuation of the coastal areas, or you could actually limit the development of the coastal areas that are likely to be affected by the wave height.

The tsunami wave height is governed by the type of activity associated with the tsunamigenic source, whether the tsunami is generated by a fault that is breaking towards a given site or away from a given site for one, then what kind of mechanism is related to the generation of tsunami wave? What kind of sea floor disturbance is causing the tsunami waves to generate? In other words, whether the waves are getting generated by an underwater land slide or by a reverse faulting or by normal faulting and what is important in this particular case is the pattern of seafloor deformation and how the deformation is propagating in a certain direction along the seafloor.

So, these are factors that are one of the paramount considerations in estimating tsunami wave height. Then the second aspect that governs tsunami wave height is near shore bathymetry and coastline configuration. Basically, what happens in areas where the coast line actually projects or thrusts towards the sea; this type of head grounds, they are more susceptible to tsunami damage, because in those situations, the energy that propagates with tsunami wave get focused towards the portion of the land that is jutting into the sea.

And that is illustrated by the by the sketch near the bottom right of this particular slide. Here you can see that the land mass is jutting into the sea as indicated in this particular as is apparent from the coastline configuration, and here the coast line is this one which is pretty obvious. And the bathymetry of the seafloor or the water depths are indicated by schematically the contours are denoted by broken thick whites lines on this particular sketch.

Now here the waves are going to bend towards the narrow portion of the coastal configuration, because of the fact that the waves are going to get slowed down at shallow water areas. And that is going to cause the waves to refract and focus its energy towards the narrow portion that is jutting into the sea. And because of the energy focusing, the area shown here this particular area is going to be more susceptible to tsunami hazard. And what actually helps us though is if there is any presence of coral reef or mangroves, along the coastline or at some distance away from the coastline, then that actually eats up the energy that is propagating with the tsunami wave and that mitigates the hazard to a great extent.

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Third mitigation, basically, is there are two strategies that are there in this respect. Number one is hazard zoning of coastal areas; here we try to restrict the development within the estimated run up zone or estimated wave height of tsunami. And secondly, construction of breakwater and levees some distance away from the shoreline that is under the influence of tsunami waves. Detection warning and evacuation is the other part of the mitigation strategy; this may not work very well for near shore near site tsunamis.

And in this case, detection tools include tide gages or seafloor pressure sensors, and they are connected through communications buoys to control rooms via satellites. And these control rooms typically issue tsunami warnings to the local governments for effecting the evacuation of the shoreline as the tsunami wave approaches.

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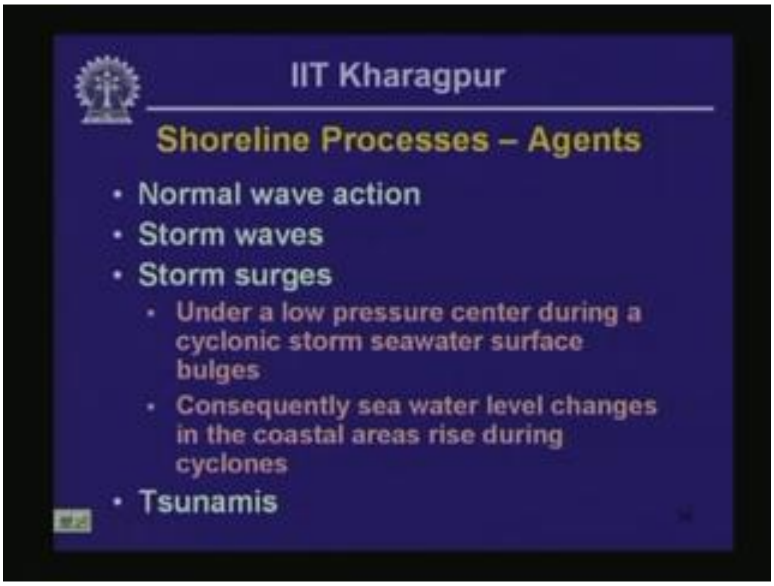

Other shoreline processes and agents include normal wave action, storm waves and storm surges. And as I have said already, storm surges are under they typically are caused by low pressure centre during a big cyclonic storm event. And because of the fact because of this low pressure centre, sea water surface bulges; it is sucked upward. And as a result, the elevation of the sea level increases greatly near the coastal areas. And tsunami also is another agent that leads to all these shoreline processes.

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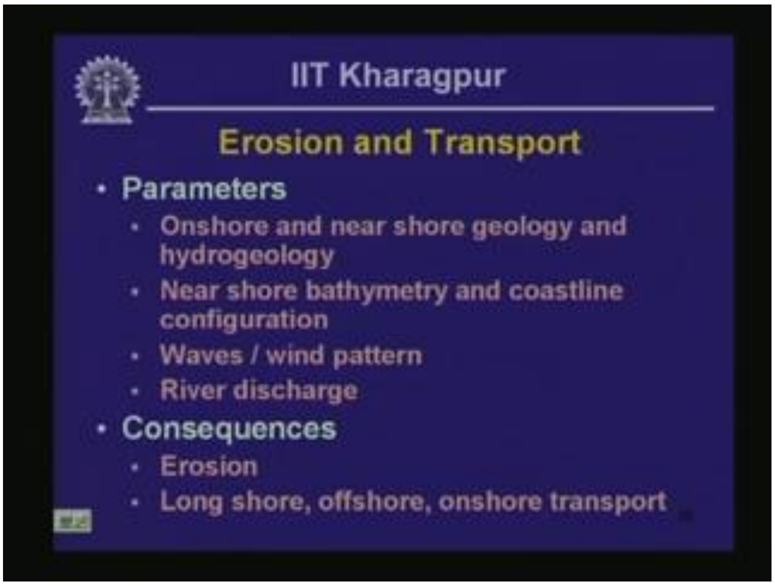

Erosion and transport is the consequence of these shoreline processes. One of the major consequences of these shoreline processes is erosion and transport. This is over and above the loss of life and property that is caused by the action of the waves themselves. And as engineering geologist, we are mostly linked with the mitigation of the hazards associated with erosion and transport due to all different shoreline processes that we listed a few minutes back.

Parameters controlling erosion and transport include onshore, near shore, geology and hydrogeology. What is the grain size, grain characteristics, what kind of vegetation is there? Whether there is any vegetation on the dune or not or on the beach or not? Then near shore bathymetry and coastline configuration, wave and wind pattern, and whether there are any water course discharging on to the shore line. Consequences are basically long shore erosion and long shore offshore and onshore transport where long shore transport is transport of eroded particles that is driven by waves that move parallel to the coast line. Offshore transport is those controlled by waves that are moving away from the coast line. And onshore transport is those caused by the waves that are moving towards the coast line.

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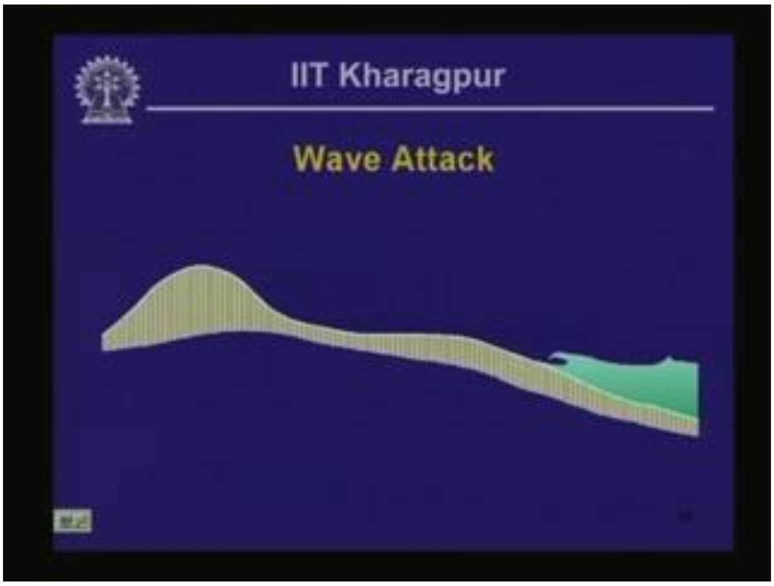

Wave attack is illustrated by this set of slides.

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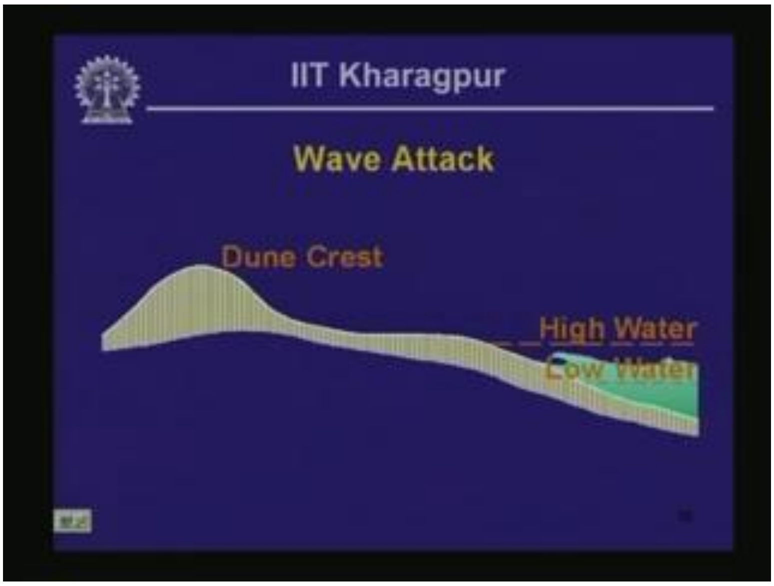

So, water level here is the normal sea water level in between low water and high tide level, low tide and high tide level. There is typically a flat lying area adjacent to the water line and that is the beach typical sea beach and on the landward end of the sea beach is often times we have got dunes that develop because of wave actions and deposition and transport.

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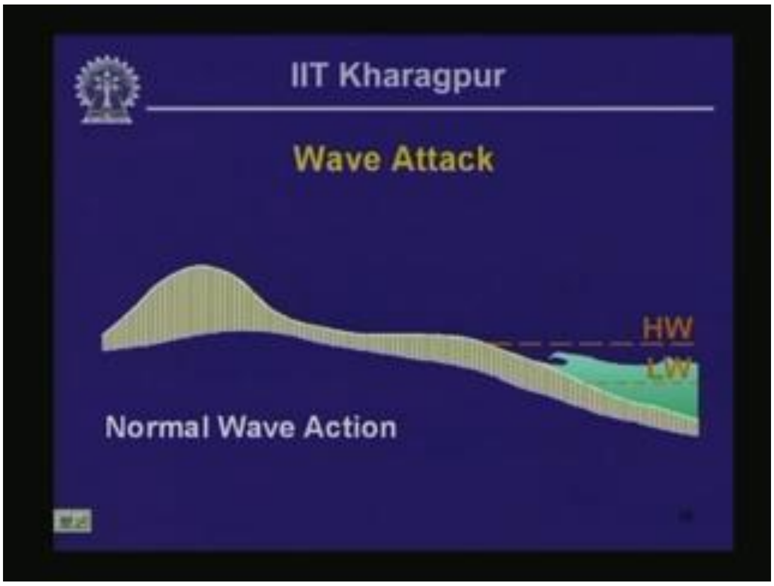

Normal wave action is then going to give rise to this type of configuration of the seafloor of the topography.

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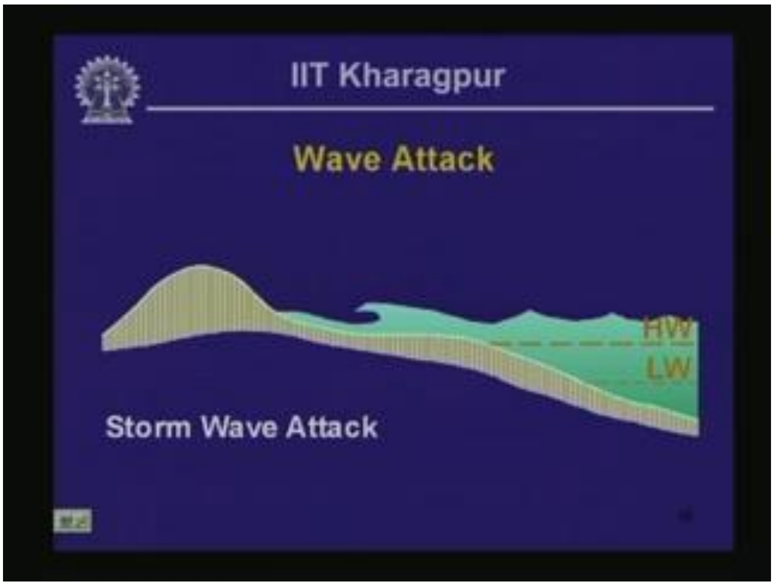

Then during storm wave attack, it is going to elevate the water height, and erosion is going to be caused by that, and the configuration is going to become like this.

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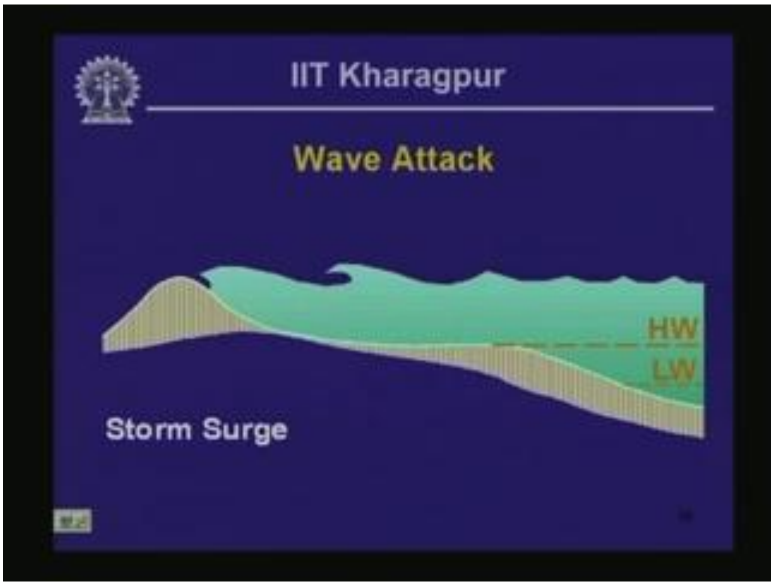

And during storm surge, again the dunes may get over topped, and this may lead to the recession of the dune.

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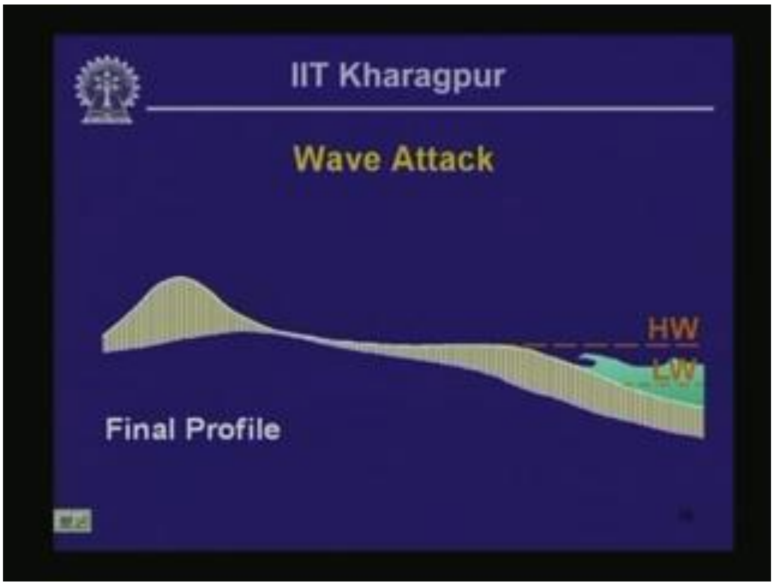

And final profile is going to be like this in this case.

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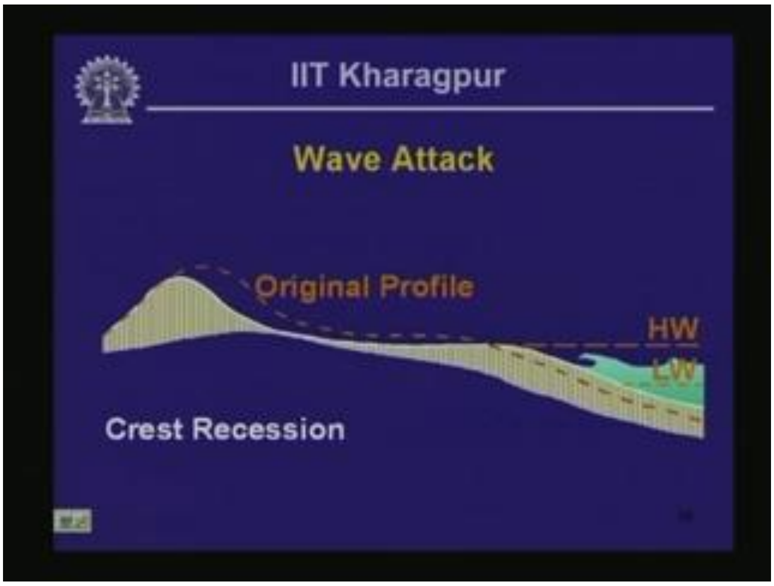

And if you superpose the original profile on top of the final profile, you can see because of the wave action, the dune crest has receded landward.

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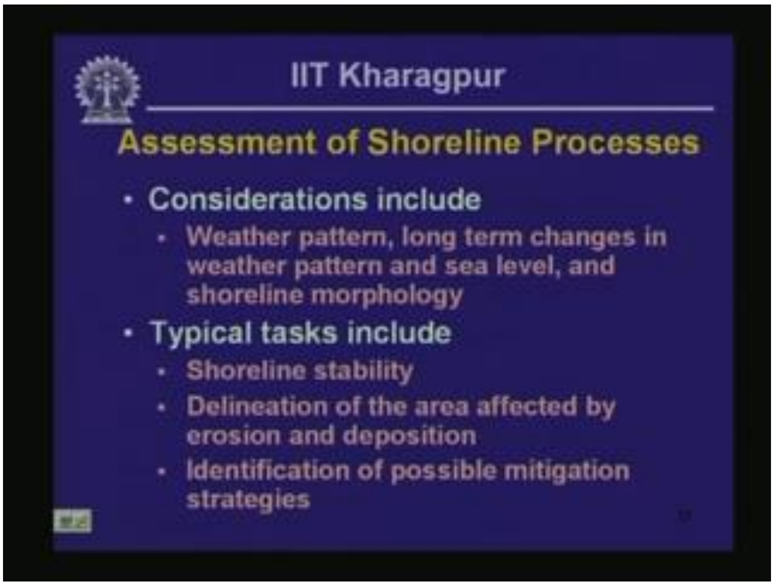

Assessment of shore line process, here we need to consider the weather pattern, long term changes in weather pattern and sea level and shoreline morphology. Typical tasks here include shoreline stability. We need to delineate the area affected by erosion and deposition and identification of the possible mitigation strategies.

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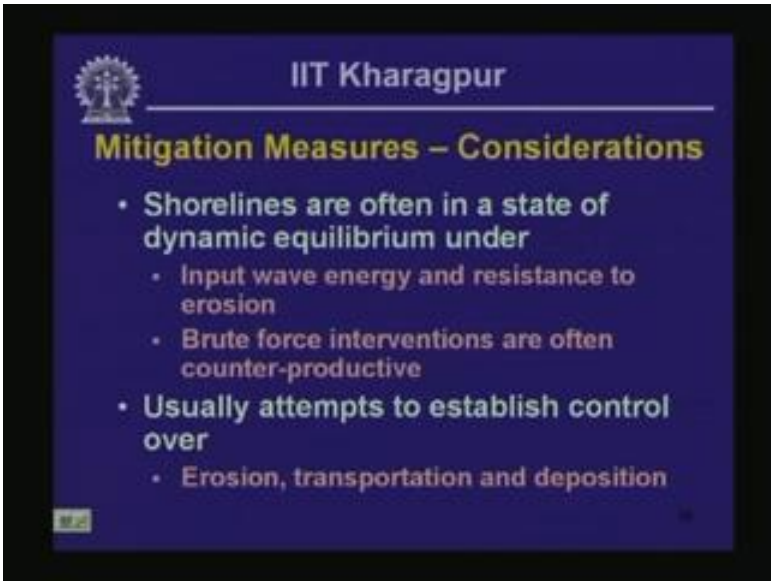

Mitigation measure, we need to consider here the shorelines; the major consideration here is that shorelines are often in a state of dynamic equilibrium under the input wave energy and resistance to erosion, and often because of this brute force intervention is often counterproductive, okay. So, what we are going to do? Actually we are going to stop the presentation here, and we are going to continue with this particular the unfinished part of this particular lesson as a part of the next lesson. So, until we meet for the next time, bye for now.

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Hello everyone and welcome back. Today, we are going to finish the unfinished discussions that we left in the last lesson, and then we are going to move ahead with geologic hazards related to landslides.

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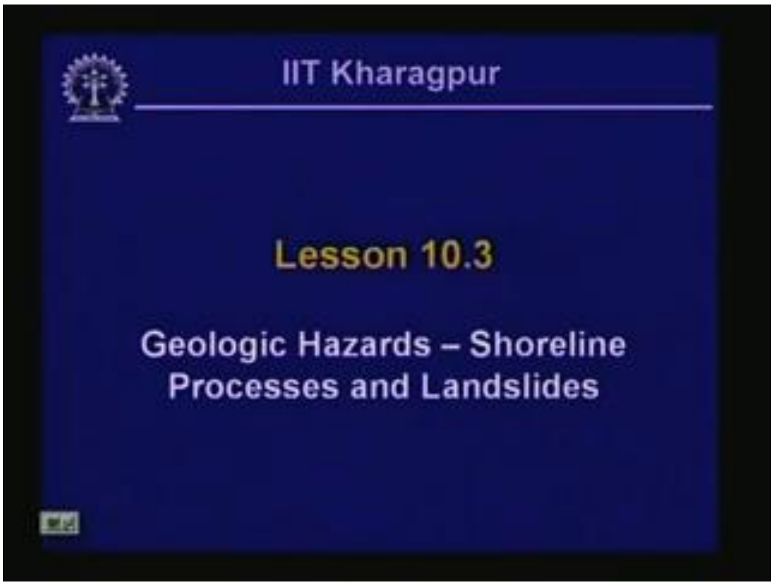

So, first of all we are going to talk about geologic hazards related to shoreline process which was really an unfinished business from the last lesson, and then we are going to move ahead with a new topic, okay.

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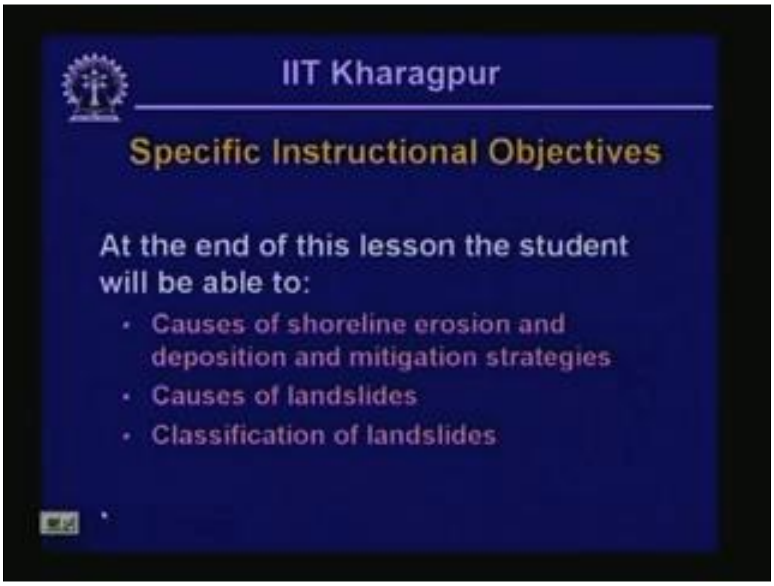

So, instructional objectives of this particular lesson are as follows. At the end of this lesson, we would like to be able to list the causes of shoreline erosion and deposition and the relevant mitigation strategies that are used to go around these problems.