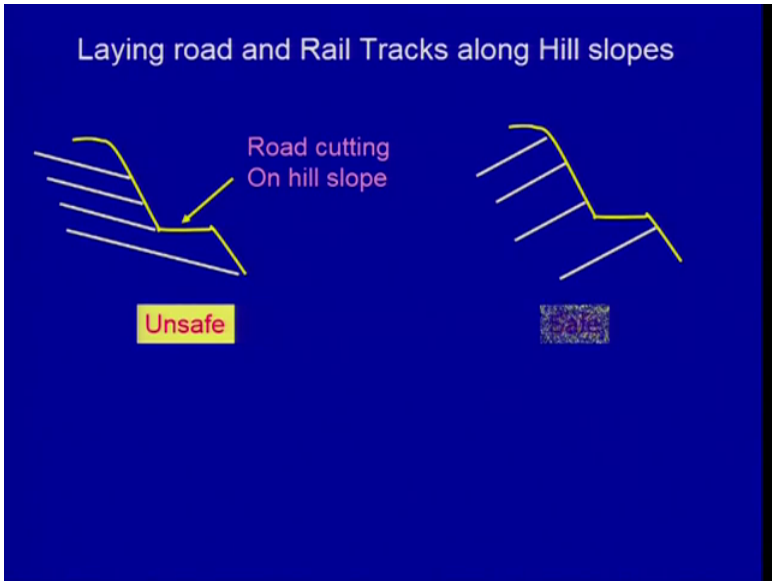
Earth Sciences for Civil Engineering Part-2
Professor Javed N Malik
Department of Earth Sciences, Indian Institute of Technology Kanpur
Civil Engineering applications - geological considerations in dams, tunnels (Part-3) & Tsunami and related hazard (Part-1)
Module 3
Lecture No 12

Welcome back.

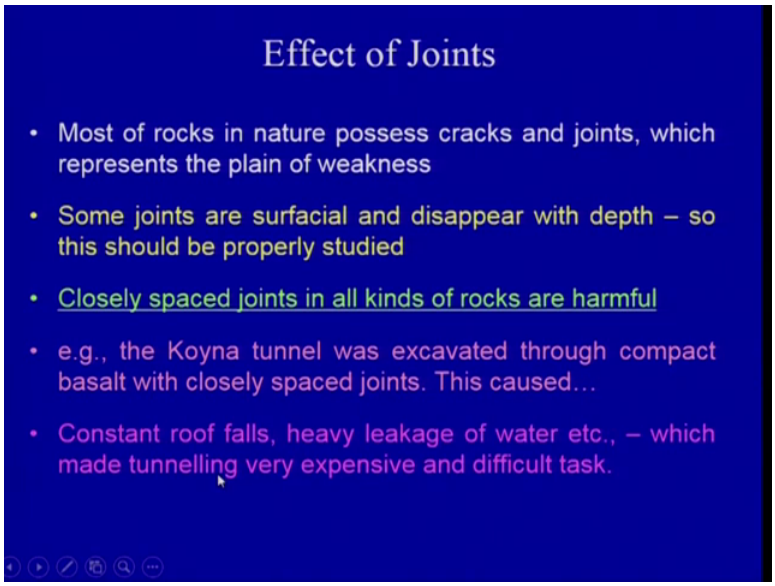
(Refer Slide Time: 0:21)



So in previous lecture we were talking about what will happen if we put the tunnels perpendicular to the fold axis okay. So as I explained in the previous one that we will across (ma) number of formations or the numbers of beds of the different rocks which is not ideal because they will have different shear strength they will have different compactness and all that and we will require multiple treatment if you are coming across different type of rock rocks okay.

So and again and in terms of syncline or anticline, this is not advisable at all okay because tunneling perpendicular to the fold axis is not at all advisable or desirable because different rock formations which you will encounter from place to place okay and that will have different shear strength and all okay so it is not advisable at all to put so only best is that if you are identifying a thicker bed okay or the thicker limb, that can be taken into consideration and it is the most ideal to put the the tunnel there.

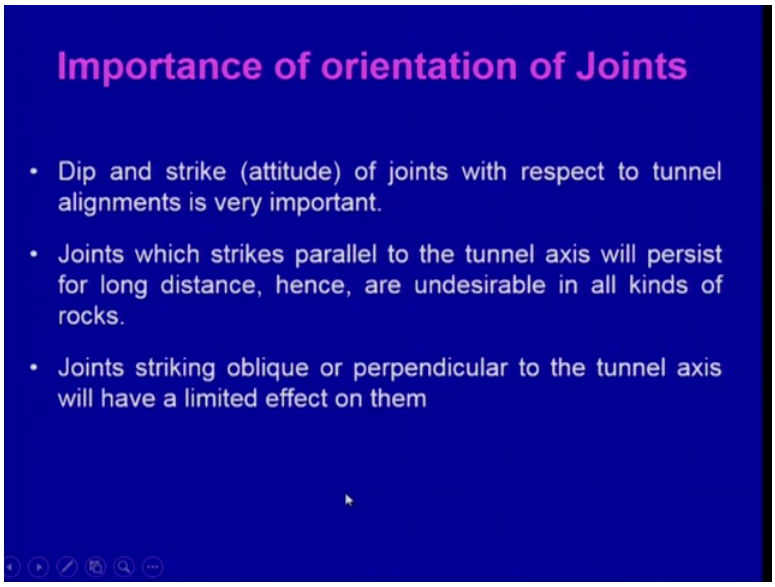
(Refer Slide Time: 1:29)



Now effect of joints again, as we were talking about that in the folded regions we will will normally come across the joints okay, but how far they are extending that is extremely important so so and mostly the joints of the fractures are the weak zones okay which will reduce the shear strength of any rocks okay. So some joints are surfacial and disappear with depth okay, they will not extend up to the greater depth so this should be okay properly studied okay.

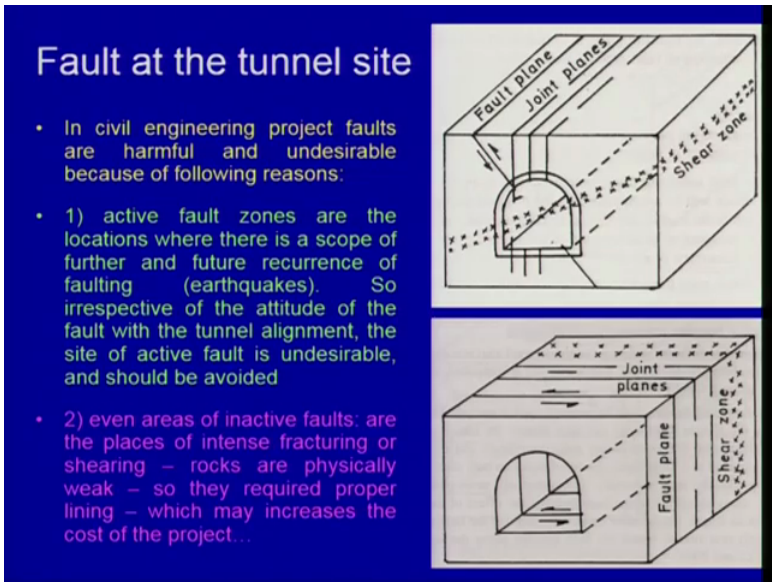
Close space joints in all kinds of the rocks are harmful okay so what we have to talk about the spacing of the the joints, we have to talk about that how how long the joint goes okay that is in terms of the the surface extent okay and also we talk about that how much how deep the these joints will be okay. So for example in Koyna tunnel which was excavated the through the compact basalt okay within closely space joints okay this caused problems okay so constant roof falls will be there, heavy leakage of the water etc which made tunneling process a very expensive project okay and it was a difficult talk.

(Refer Slide Time: 2:51)



So importance of the orientations of the joints is extremely important, dip and strike, that is the attitude and this is important for all like folds, joints or faults okay, this we need to know okay so very important in terms of like with respect to the tunnel alignments because that will help us that how the tunnel should be aligned okay and joints which strike parallel to the tunnels, tunnel axis will persist for longer distance okay. So if you are having the strike of the joints which are parallel to the the fold axis or tunnel, they will like they will like for the for the longer distance they will see okay so that will be that we need to take care of okay. Hence it is undesirable in all kinds of rocks okay so joint striking oblique or perpendicular to the the tunnel axis okay or the fold axis we are taking okay will be further limited period okay like limited area it will be covered otherwise we will have it. So this one has to take into consideration okay.

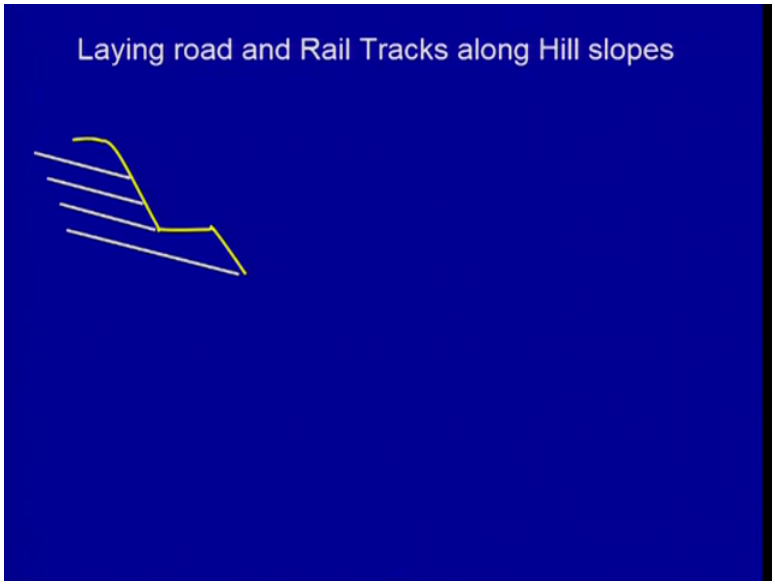
(Refer Slide Time: 3:58)



Now falls at the tunnel side, again, this is a what has been shown so in the previous, what we were talking about that if you are having the joints which are parallel to the the tunnels or the tunnel axis or the fold axis okay then it will be it will it will persist for this but not in most cases we will be able to see that okay. And then if the fault is of course on the surface, it is away here we have the fault plain which is crossing the the tunnel which is not advisable okay and but in some places if they are having the at at few locations where the fault is passed it could be good side okay.

So in civil engineering projects, the faults are harmful and undesirable because of the following reasons. Because the active fault zones are the locations where there is a scope of further or future recurrence recurring of the of the earthquake okay. But the most likely place where which will be the source for the large magnitude earthquake in (neach) near future okay so irrespective of the attitude of the the tunnels, okay. The that is the alignment okay, this should be avoided. Even areas of inactive faults are the places of intense fracturing and shear zones will be there so hence those requires proper lining and which can in sense increase the project cost okay.

(Refer Slide Time: 5:35)



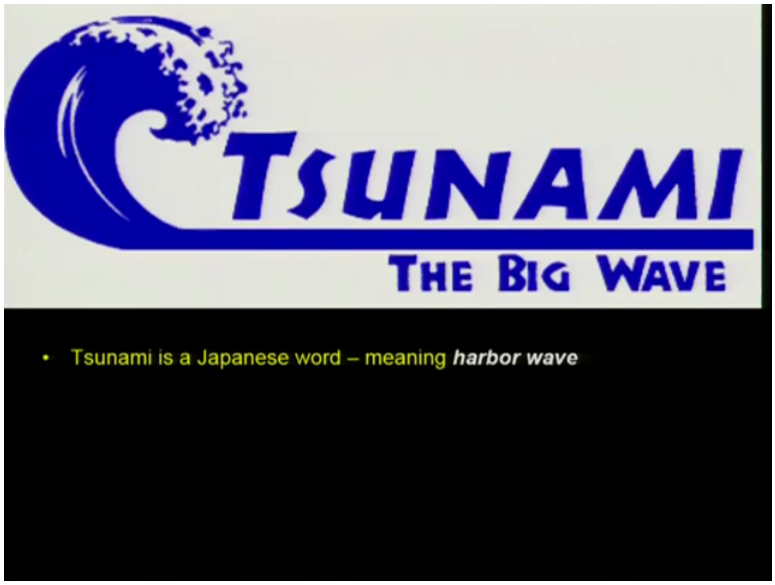
That's just an example here. Suppose we are having in we are laying the road at the edge of the folded structure and if we come across the beddings which are dipping towards the the road okay and another location is that this is unsafe but another location where we are having the beds which are dipping in the opposite direction from the road okay, these are safer places to be done. And of course (ma) nowadays we have like putting the concrete covers and all that okay to avoid the land slip here okay but these are the dangerous locations if we are not properly taking into consideration the dip or the attitude of the rocks okay.

So I will end here and I will start with the new topic. Um that is on Tsunamis okay so let us move to the new topic. So we talked about the faults, folds and all that. Now this another very important aspect which we should learn, we should understand the process and we should also know the areas which will which are vulnerable or at are at risk from this type of hazard, that's the Tsunami okay.

(Refer Slide Time: 6:55)

And in this event jolted the the Indian subcontinent and the neighboring areas which are adjoining the Indian ocean during 2004 Sumatra Andaman Tsunami okay and we were not very much prepared about such events and because of lack of understanding, because of lack of historical documents and all that but of course now the studies suggest clearly that the was not the only event which occurred in the in this region but in the past we have similar giant Tsunamis triggered by mega subduction zone earthquakes in that particular region that is Sumatra Andaman subduction zone okay.

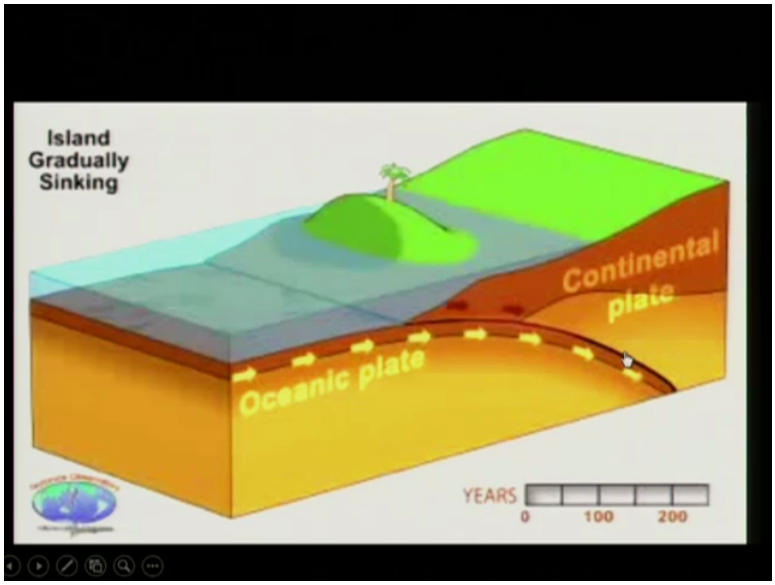
(Refer Slide Time: 7:51)

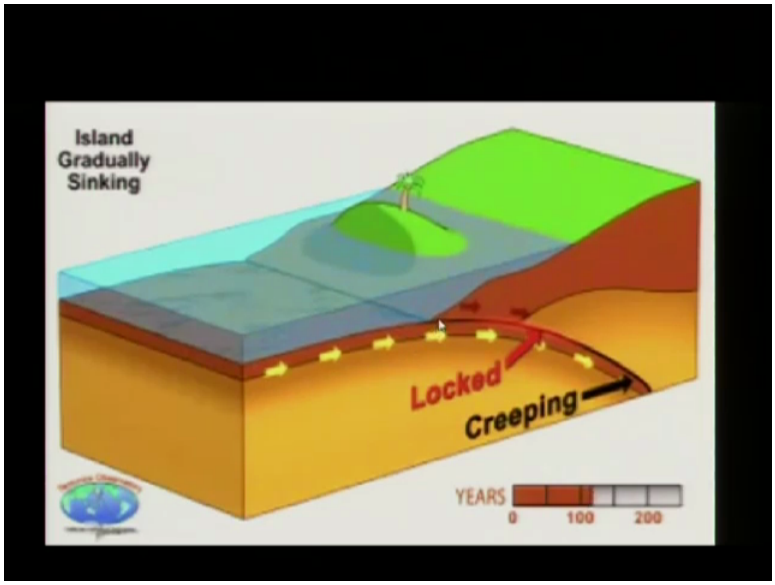


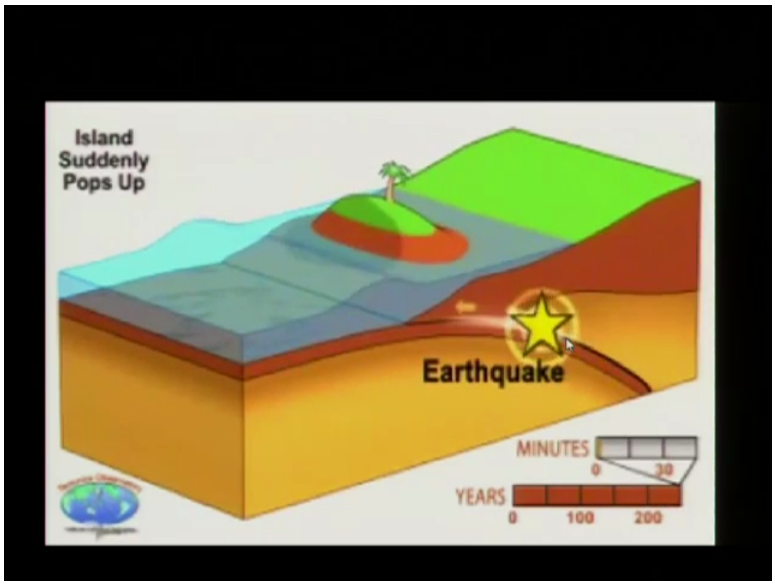
So let us talk about the Tsunami, what exactly it means and how it is been triggered okay. So Tsunami words come from the Japanese literature and they it means the harbor wave okay. And height of this wave is a small and barely noticeable in deep ocean because the wavelength will be very high, a very large wavelengths and the the height will be we will not be able to see because the height of this wave is very small and barely noticeable in the deep ocean but it becomes larger and damaging when it approaches the coast okay because as it approaches the coast, it will stack up. All the waves will stack up and result into the almost like an sea wall okay and that what is what was been experienced in 2004 Sumatra Andaman earthquake and similar things were been experienced in 2011 Tohoku earthquake in Japan.

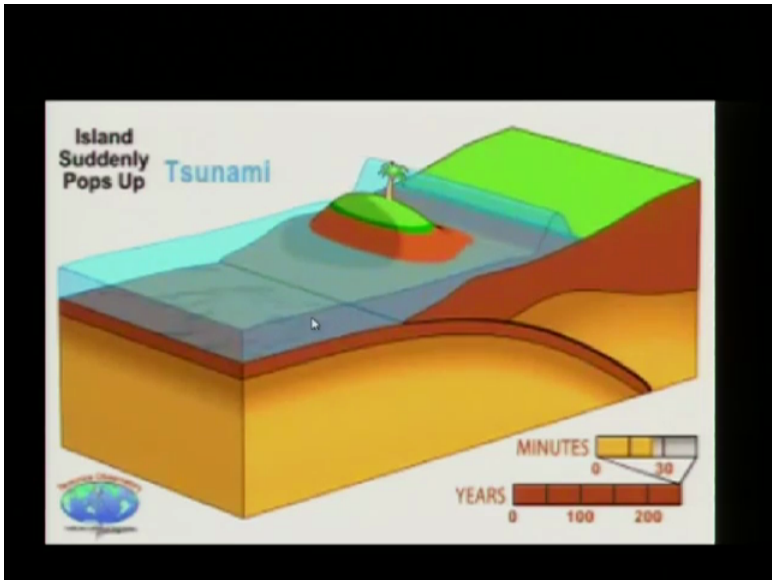
So what they say is big wave okay so wave will be extremely largely, it will develop then because of the stacking okay so in ocean it will be barely noticeable and this was also even like experienced by the fishermans okay on the boats which were sailing at that time in the Indian ocean, that they were not affected at all by that Tsunami but when they reached the coast, they found that there was huge damage and that was resulted because of the the deadly Tsunami.

(Refer Slide Time: 9:24) 04







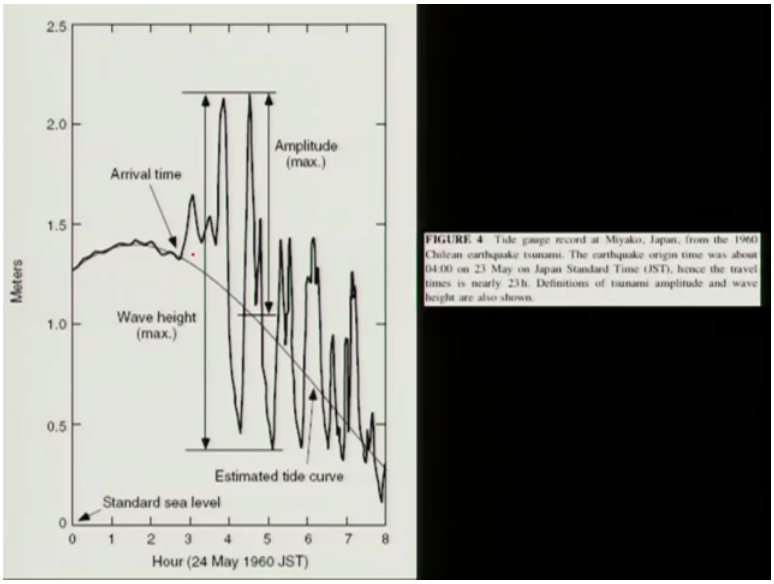


So this what usually happens okay so this the cartoon which shows the the oceanic plate subducting below the continental plate here. It can be in combination of oceanic of the content here, there should not be any problem. Now when this keep on moving okay, there is an strain which is developing here so this part is locked actually. This part is locked over here and the finally it will release the pressure okay and that will be an earthquake and because of the sudden displacement of the water here, you will experience a Tsunami okay and that what has been shown here.

I will play it again. You please carefully watch this okay. So you are having an you have locking here, at this place and this area got uplifted okay. When when this plate was moving down, this area got up so you will see that also or it may subside also okay. This may subside and then it was been released so there will be (cha) the water column was been displaced here and then at the same time, you will also have the land level change because this this island, the land, the level of this island got changed okay so this, let us see again okay.

So what it has been shown here, now this area got uplifted okay. This area got uplifted and then you had a massive Tsunami here okay. So this what happens, now this is an example the Chilean earthquake. This is one of the largest earthquake so far recorded the in the history of earth okay. We don't know about the past okay but this was the the largest one until recorded okay. 9.5, Chilean earthquake of 1960 and if you if you see this graph here it shows that the arrival time of the Tsunami okay.

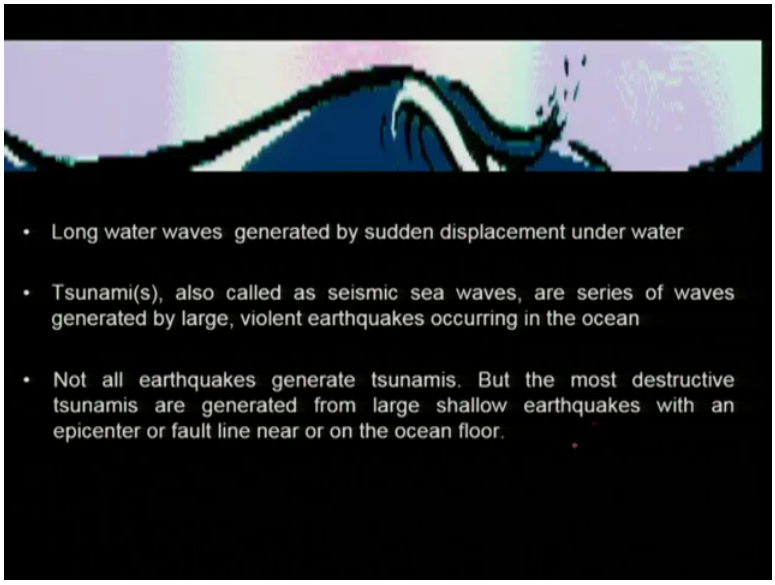
(Refer Slide Time: 12:10)



This is tidal (cha) the tidal curve okay, we are getting okay so the tidal graph show the sudden change in the amplitude of the over here okay. So this is what we you see the rise in the amplitude, the maximum amplitude goes up and then so this is the normal curve of that okay so estimated up and down, up and down this is the the average of the Tsunami tidal tidal curve okay

so high tide, low tide, high tide, low tide but here what you see is the massive change which was been noticed at that time okay.

(Refer Slide Time: 12:26)

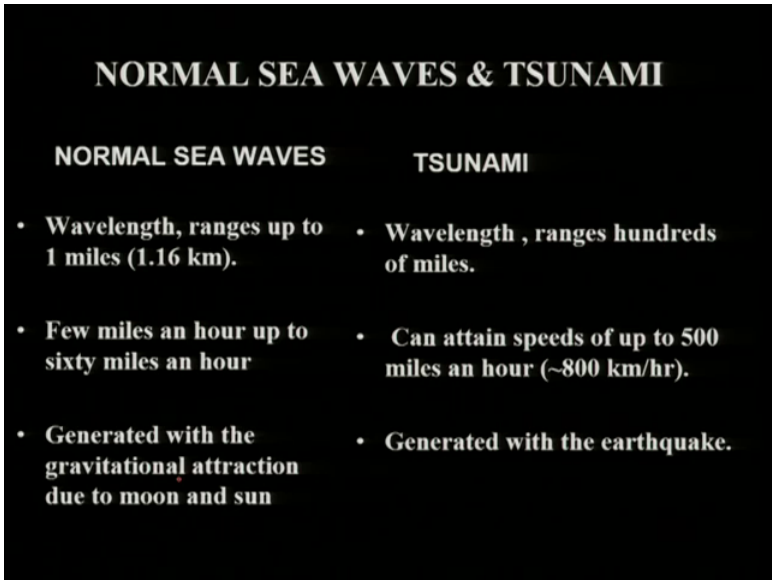


So long water waves generated by sudden displacement of under water so this displacement was along the plate boundaries so we have the long wave which will be generated, Tsunamis are called as, also are called as seismic waves okay, sea waves generated by large violent earthquakes occurring in the ocean okay. Now this is not always like the there is an experience, a Tsunami can be generated by any water body because of the sudden displacement of the water column okay. That is possible so if you are having a meteoritic impact also, that can happen that can result into the Tsunami and may be much more violent Tsunami.

Then submarine landslides can also trigger Tsunamis okay because it will result into the disturbance on the of the water column on sitting on the top of that. So sudden displacement under water that is in the sea or anywhere in the the huge reservoirs, it will be result into the formation of the Tsunami. That is the seismic sea water wave okay, they are having the sea wave or so not all earthquake generate Tsunamis, not necessarily because if there is a less displacement and less displacement of the water column, it will not trigger the the Tsunami. May be the Tsunami will go unnoticeable okay but most of the destructive Tsunamis are generated from

large shallow earthquakes okay so if the the earthquakes energy is released at the shallow depth then that will result into the the Tsunamis okay.

(Refer Slide Time: 14:10)

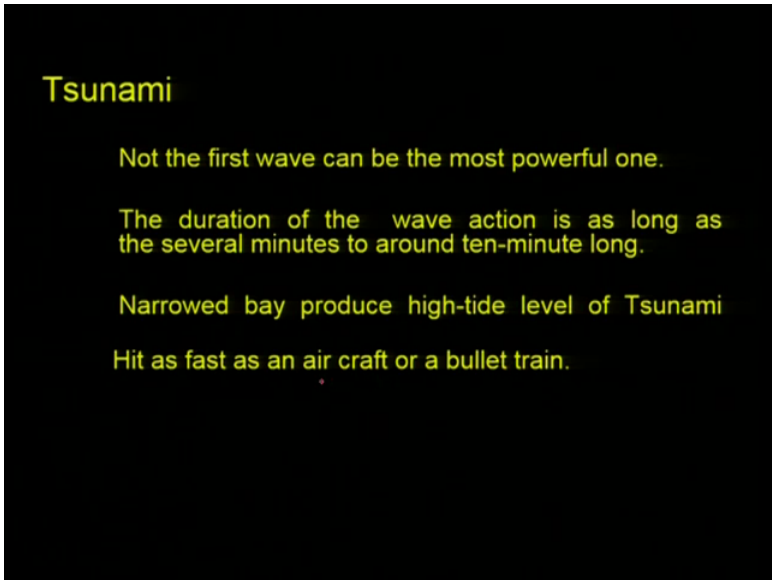


So normal sea waves and the sea waves, if we compare that okay then what you will be able to see is, the normal sea waves and the Tsunami waves, wavelength ranges up to 1 mile or 1.6, 1.16 kilometers okay whereas here, in terms of the Tsunamis the wavelength can range up to 100s of 100s of meters okay or 100s of kilometers. It can it can range into that okay so around a kilometer but you are having more 100s of kilometers okay. Few miles an hour up to 60 miles an hour it can travel but here it can travel at very high speed okay or very velocity is almost like a jet plane. 800 kilometers per hours so it travels very fast, that is the velocity is very high.

These are generated because of the gravitational attraction of the sun moon and sun but these are generated by earthquakes okay. The mega Tsunamis are always triggered by earthquakes okay so these are the major difference between the two, the normal sea waves, the wavelength ranges for few kilometers whereas the wavelength ranges for 100s of kilometers okay and they they few miles, they this the velocity is not so high but here the velocity goes around 800 kilometers or more okay per hour okay and these are mainly because of the attraction between the sun and moon but here we are having because mostly because of the earthquake and as I mentioned that other than the earthquakes, the other sources for triggering earthquakes are the submarine

landslides, we are having meteoritic impact okays so those are the other things which we are having.

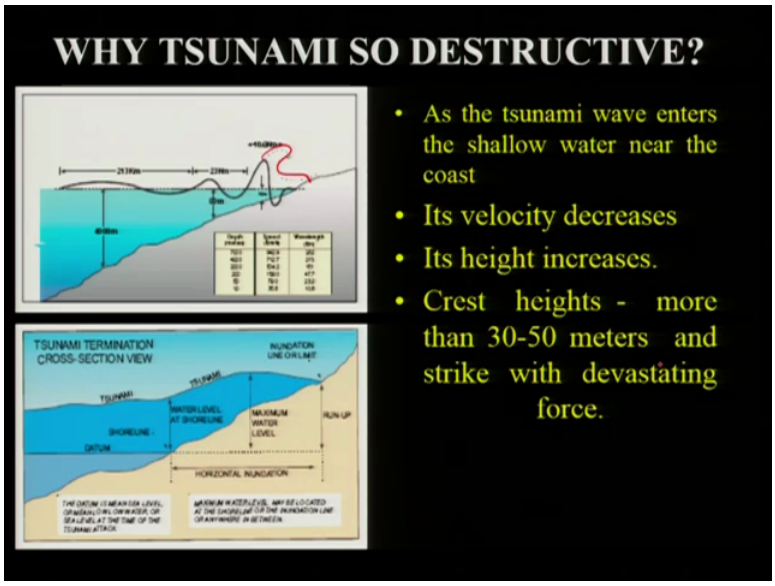
(Refer Slide Time: 16:11)



Now Tsunami is usually not first wave can be the most powerful one okay and in most of the cases this was been noticed okay but not the first wave was very powerful so people thought that okay nothing will happen but the second wave or the third wave was massive and destructive okay. The duration of the wave action is as long as several minutes okay to around 10 minutes of longer so that is, that depends on the that how what will do, what is the wavelength and all that okay depending on that, you will have the difference between the 2 waves okay which are coming okay.

Narrowed bay produces high tide levels of Tsunami okay so if you having, so this is this here, the important comes of what is the configuration of your coast line okay. So if you are having different like open coastline then the effect will be different. If you are having narrow coast line then the effect will be different of the Tsunami, if you are having rocky coast line then the effect will be different okay. Hits as fast as the aircraft or the bullet train, it is more than okay. The fastest bullet train might be 350 kilometers or so or may be faster than that but aircraft is around 800 to 900 kilometers per hour. Jet planes mostly so it has tremendous speed okay.

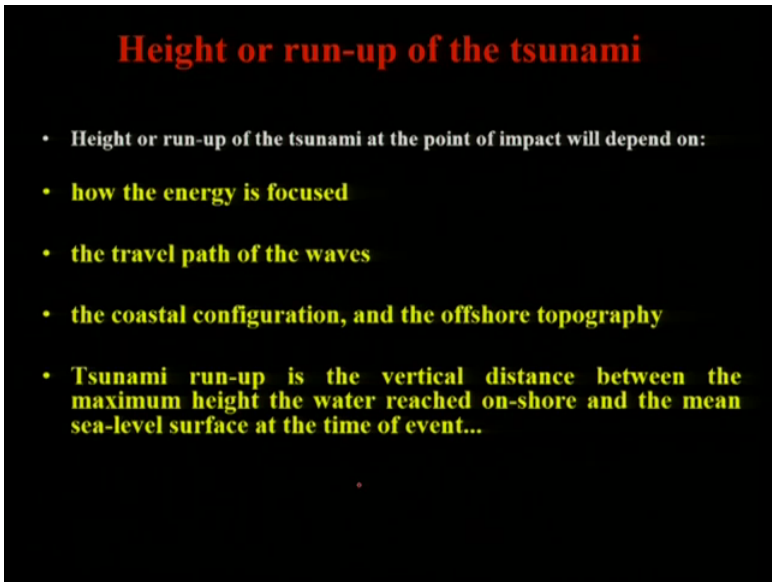
(Refer Slide Time: 17:50)



Now why is Tsunami so destructive okay? This is what we were talking about that in ocean okay the wavelength will be too large and the height will be too less okay. So large wavelength less height in the deeper part of the ocean but as it becomes shallower and shallower okay, the it will reduces, it reduces the wavelength and the height increase okay so reduction in wavelength, height increases and then stacking up of these waves will result into the giant Tsunamis. This will result into the giant Tsunami so that is what the difference you will see okay.

So as the Tsunami enters, the shallow waters near the coast, its velocity decreases but the height okay the velocity decreases, the wavelength decreases okay but the height increases so when it enters the shallow waters, the height will increase, that is extremely dangerous okay so crust heights more than 30 to 50 meters have been reported in some places okay so this is one of the reason for that why it is so destructive in terms of when it reaches the coast okay otherwise it is barely noticeable in the ocean.

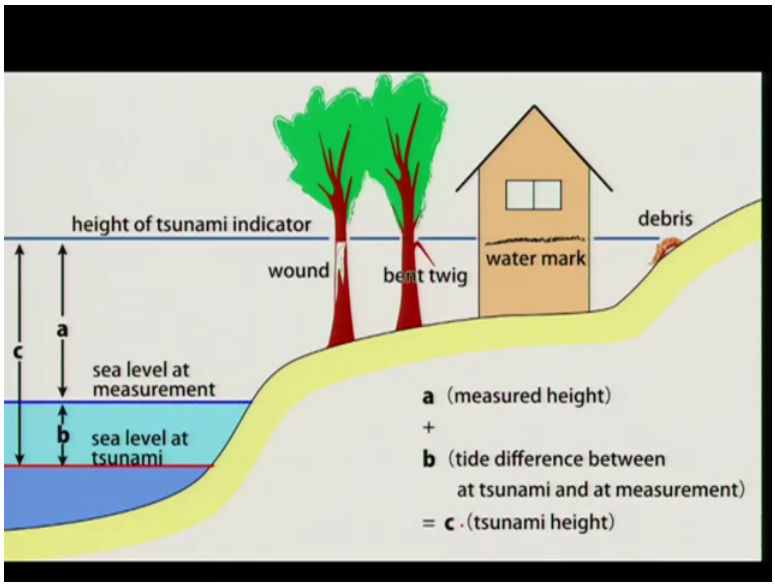
(Refer Slide Time: 19:17)



So height and run up of the Tsunamis are extremely important and this usually we we measure the heights and run ups, okay height of the run up, height of the the Tsunamis after the event because this record is extremely important and it can be used for modeling purposes and can be used to generate Tsunami hazard maps okay because this information has to be passed onto the the administration okay which can say that okay fine this areas are not safe and you need to move to the higher grounds when there is an Tsunami warning if it is in it is issued if at all it is issued so height or the run up of the Tsunami at that point of impact will depend on okay.

This is again, it will change okay like it depends on how the energy is focused, from where the water is coming in okay that important and your location and the travel depth of the water either your location is very you are having shallow shelf or you are having a deeper one okay or that inclined one. Coastal geomorphology is extremely important. That is the off shore topography okay. Tsunami run up is the vertical distance between the maximum height of the water released on shore and the mean sea level surface at the time of the event okay so the difference you are taking actually okay. The difference between these 2 so the time of the sea level at the during the event and then you are having the, that how far reached so that level difference you will take okay. So let us see in (ano) another slide how we have taken into consideration okay this one yeah.

(Refer Slide Time: 21:02)



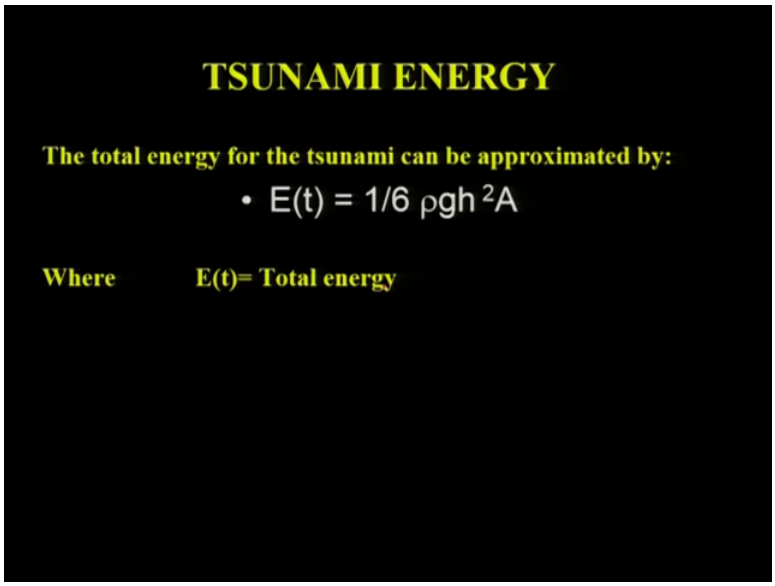
So here it explains that you are having the this blue one this is this is the sea level you are having and A what you see is the measured height okay so the measured height at the time of the event okay and then B is your this one, the difference. That the tidal difference between ub the time, at the time of the Tsunami and at the time of the measurement you are taking into consideration okay. So you are having this difference, you are having this difference this will give the additions will give you the Tsunami height okay because we are taking the height from here the extreme end up to where it reached okay.

And then these are this can be taken up after Tsunami we see that then how far the (Tsuna) debris were been transported and then how how these water marks on either building or any other structures, we will see because there will be some residence time of the water which will remain here which will result into the the development for the watermark and then the the bend of the twins because when the water comes in, it will try to break the twigs and all that or that small branches.

That can also be taken into consideration and then wounded trees okay tree can be if at all they are they are alive and they are standing otherwise most of the trees will be uprooted so if we find such wounded trees and the bend twins, water marks and debris, that helps us un putting the the final height of the of the Tsunami run ups okay so this helps us in talking about that okay fine if

this magnitude earthquake occurs in near future, these areas will be getting inundated okay so this is extremely important for us to mark the run up heights okay after every events okay. So this is the difference between that, the sea is the edition of what we are having the this is the Tsunami, the height of the (Tsun) the sea level at the time of the measurements what has been okay and then finally we will come across the the height sea. Okay.

(Refer Slide Time: 23:34)



You can also talk about you can calculate the energy okay of all the Tsunami with this equation where ET is the total energy, how much energy will be released. Okay we will stop here and then will continue in the next lecture.