Geomorphology
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Lecture - 37
Coastal Geomorphology - IV

So friends good morning welcome to this lecture series of geomorphology and especially this is coastal geomorphology we are discussing here. In the last class if you remember we are talking something about the coastal abrasion ramp and we found this is a gentle sloping surface into the sea and its width depends upon this wave energy, depends upon the rock types and depending upon the nature of erosion of this sea cliff.

And we found that there is a thin sediment cover on it and gradually the coarser side is towards the coast and the finer side is towards the ocean and this abrasion ramp it develops mostly in the volcanic rocks. So if you compare this abrasion ramp to this Hawaiian Islands to other part then we will find the Hawaiian Islands they develop very smooth and well developed coastal ramp as compared to others.

Similarly, there were the solution surface or solution ramps are there. So it is mostly by this carbonate rocks and this carbonate rocks on which their algal mats grow and finally we get disconnected pools and somehow heaps like that. So this was all about our abrasion ramp along the coastal system. So today we will discuss about this equilibrium and disequilibrium about this coastal system. What does it mean? What do we mean by equilibrium form of shore platform?

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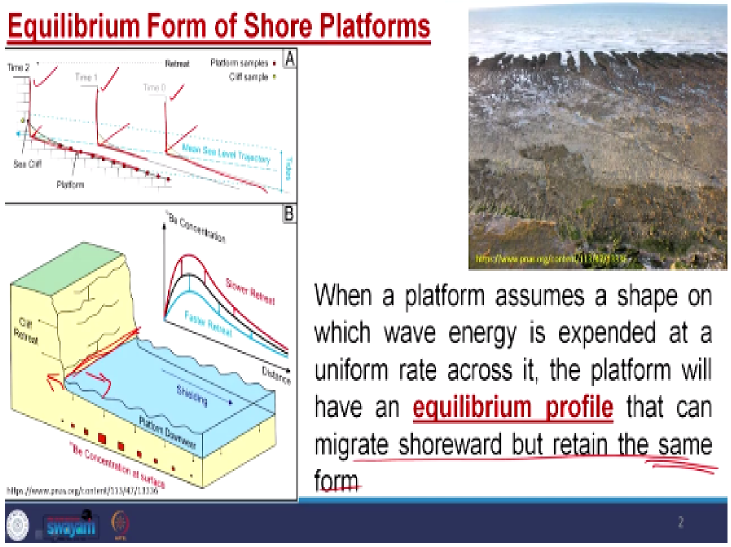

So if you see here when a platform assumes a shape on which wave energy is expended at uniform rate then that is called this or this profile this coastal system that is called it is in equilibrium profile or the coastal profile is said to be equilibrium profile. So that means if you see the equilibrium profile that can migrate shoreward, but retain the same form that means it is the uniform rate of energy expenditure along this coast.

So as you know we are talking something about this coast it is somewhat unevenness is there, but due to this wave action with repeated wave action this tapering ends of this coast they become eroded and it is deposited and the concave part of this coast and finally with time this coast becomes straight. So if the straightness of this coastal profile that retreat uniformly or it grows uniformly.

Then this type of coast are called equilibrium coast or equilibrium profile of this coast. So that can migrate shoreward, but retain the same form that means the straightness will be there. For example, if you see here the coast is straight and either it is migrating this one or it is building up towards this one. So this straightness will be maintained so that it is called an equilibrium coast.

Similarly, here if you see here 3 figures it is Time 0, Time 1 and Time 2. If you see here this was the profile at Time 0 and this was Time 2 and this is Time 1 and Time 0. You see here the straightness remain same, straightness remain same. So that type of profile will be said to be equilibrium profile.

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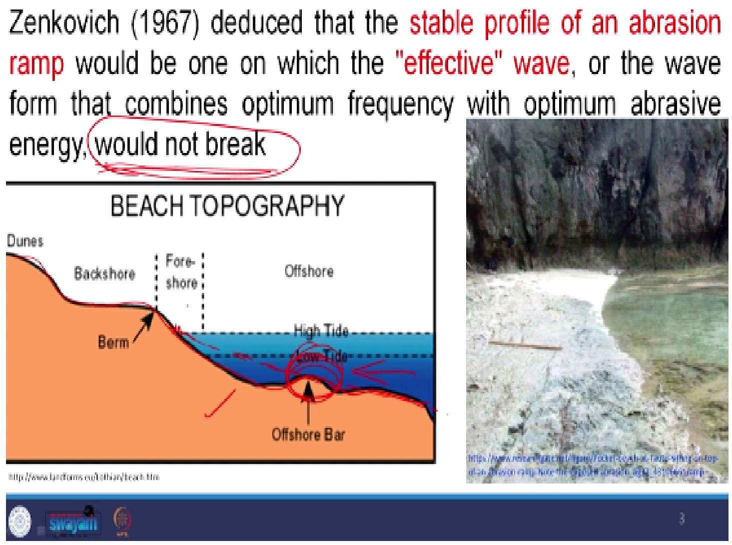

So this gentlemen 1967 deduced that this stable profile of an abrasion ramp would be one at which effective wave or the wave form that combines optimum frequency with optimum abrasive energy would not break. This is important to understand here. So in equilibrium profile that means here the effective wave that means those wave who are affecting on the coast there are number of waves.

But some of this wave that disappeared within that system, within the marine system some of this waves their energy is so much and after dissipating the energy some of this energy is travelled or it is transformed to the coast and it is expended along this coastal profiles. So those effective waves that would not break so that means once there is a breakage of these wave system then there should be unevenness along this coast.

So that means by this definition it says there will be no unevenness along this coastal profile if you are moving from the coast towards the sea you will find it is an uniform slope, there is no undulation along this or across this coastal system. So for example if you see here whatever this figure appears here to be you see the coast it is moving like this. So it is not an equilibrium coast because here this whatever this wave energy is coming.

And it will hit here and will finally it will break or once the system breaks that means there is unevenness along this coastal profile. So that means as per this definition it says the effective wave would not break. So that means as per this definition says these coastal profile should be like this instead of like this. So that is why it says if the effective wave will not break that means this wave will directly hit to this coast without breaking.

And that wave or that type of profile is said to be of a stable profile or stable abrasion profile will be or stable abrasion ramp will be there along this coast so that this wave will not break within this system within near approaching to the coast and directly the wave will hit here. So that will called then equilibrium profile.

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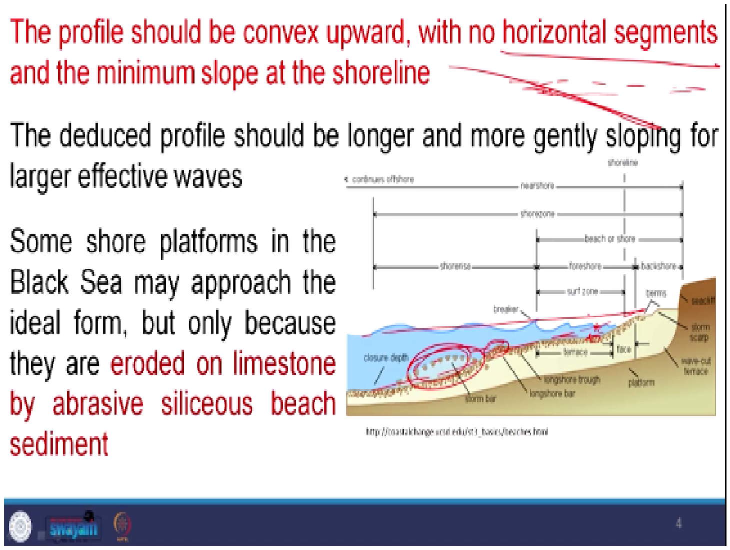

The profile should be convex upward with no horizontal segments and the minimum slope at the shoreline this is very important to understand here. The coastal profile it should be convex upwards like this. It should be convex upward that means if it is mean sea level like this there you see there is no unevenness there will be no breakage so the direct hit of this wave will be at this position.

So its profile should be convex upward with no horizontal segment that means no horizontal segment will be there and the minimum slope at the shoreline. So here if it is shoreline is there the minimum slope should be there and finally there will be no concavity or no straightness within that profile. The deduced profile should be longer and gentler sloping for larger effective waves.

If you see here if it will be like that so for example if it would have been like this so that means there will be no convexity here, there would be no convexity here and there will be no concavity here. So there will be effective wave that will directly hit here. So that means this deduced profile should be longer and more gentle sloping for larger effective wave and larger effective wave more effective wave will be there.

More coastal erosion will be there, more coastal retreat will be there. So that this coastal retreat should be uniform because had it been a convexity would be here. So that means if you are looking a cross section, but if you are looking a plan view that means in this area corresponding area there will be less effect of the wave, but adjacent to this there will be more effect. So that un-uniformness of erosion, un-uniform where erosion will be there.

And finally the coast line or coast profile will not straight it will be zigzag pattern. So that is not an profile of equilibrium condition. Some shore platforms in the black sea may approach this idle form, but only because they are eroded or limestone by abrasive siliceous beach sediment. It is here to understand about hardness of the system. Now you see we have limestone and we have sand of siliceous region.

So now if a limestone is allowed to be robbed through this sands repeatedly so that there will be rapid erosion of this limestone because the hardness difference is there. So this type of erosion, this type of profile has been reached by black sea where this surrounding is the limestone and the sand particles along this coast is of siliceous origin. So due to continuous abrasive action of those sand the limestone becomes eroded very smoothly. So that the stable profile or the equilibrium profile has been maintained there.

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Then another component of this coast is called the coastal cliff. What is coastal cliff? Cliff means it is a vertical surface. So vertical surface along the coast is called coastal cliff and if you remember when we are talking about this mass wasting. So in the mass wasting along this slope we have a cliff surface through which there will be freefall of material and similarly the coastal cliff that means here is also the same fundamental is there.

It is vertically or near vertical sloping surface on which the mass movement will be there and effective mass movement is due to fall. So if you see here the cliff that rise from this break of this shore platform are commonly called wave cut cliff. For example, here 2 photographs are given one is here and another is here. If you see this cliff it is called wave cut cliff. Why wave cut because there will be direct hit of wave in this region, direct hit of wave.

So that this rock will be eroded from this region and it is called wave cut cliff. Okay but as with any subaerial escarpment mass wasting is the dominant process of cliff retreat. Here comes the mass wasting our earlier classes because wave only hit here it will erode here, but the instability if you see here this instability of this part it is this fracture along this fracture this total mass will fall.

Here if you see a wave shaped mass you see it is removed here. So that means whatever the mass is coming to this coast it is due to the mass wasting process it is not the wave, wave whatever wave creates the instability of this cliffs because we have wave cut suppose we are creating a notch here, we are creating a notch here. So once we are creating a notch here that means we are making the system unstable.

So once this system becomes unstable this part it falls down here, this part it falls down here. So that is due to mass wasting. Wave carrying at this cliff base keeps it fresh at this appropriate angle of repose so that this mass will fall down freely. So due to the wave quarrying or that means creating of a notch this upper part becomes unstable and finally it falls down.

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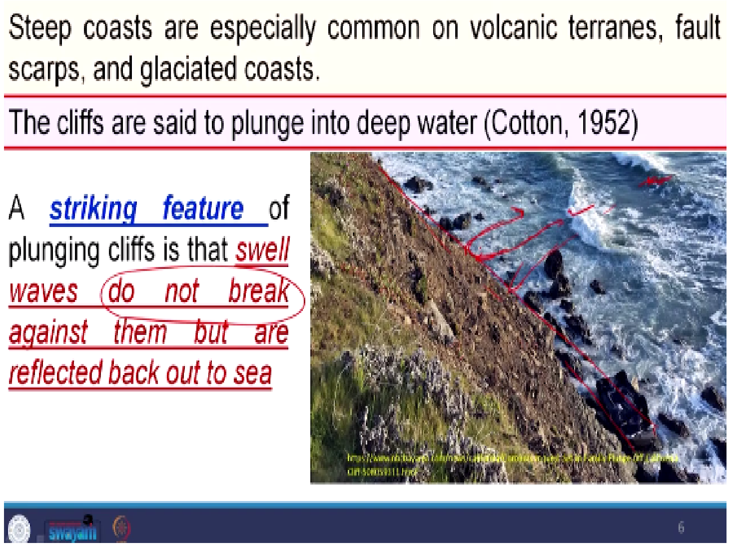

Steep coast are especially common in volcanic terranes as we have discussed in the Hawaiian system faults scarps and glaciated coast. So volcanic terranes like the Hawaiian system the fault scarps, fault scarp for example if you say about this Indian context about the western ghat, western part of this coast. So we have fault scarps and very high height are there. So that we are getting a steep coast and glaciated coast are very steep.

So this type of coast they are very prone to mass wasting or this removal of the material is due to mass wasting. The cliff are said to be plunged into the deeper part of this water. So if you see here this is a cliff surface and it is plunging into the deeper part of this water. So once it plunges so this plunge if the same slope continuous here so that means there will be less effect of breaking of this wave.

So that the wave is coming and directly hitting to this coastal system. So a striking feature of plunging cliff is that swell waves do not break against them, do not break against them, but are reflected back out to sea. Here if you see here this is the pair of swell waves are coming, wave train and it is following, waves are following behind it. So now you see as there is no unevenness of the system the wave is directly coming and hitting this surface here.

And instead of breaking this wave will reflect back again it will hit here and will reflect back. So this is the striking feature of this plunging cliff that plunges inside the deeper part of this water, but it never breaks the wave rather than it reflects back the wave.

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If a rock mass is strong enough to form a steep cliff and if that cliff happens to rise somewhat meter 10s of meters of height it is subject to only minor wave attack because you see here for example suppose we have a cliff here and this cliff is much, much more height as compared to this wave base or if you see here this is the height up to which wave can effect. So that means if some of this cliff they are much height as compared to this height of this wave attack.

Then that means it will be less effect on only minor wave it will suffer minor only wave attack so that it will be more stable. Only when the submarine talus form at the base of the cliff to create breakers can only full energy of waves can be impressed on this cliff. For example, if you see here. Now suppose we have a cliff at 10s of meter high and we are removing material.

So that material will fall in here so once it falling here so it is creating a submarine talus. We know the mass wasting talus it is the material eroded from the upper slope and it is deposited that is the slope which is just below the cliff. So that means if it is cliff so the material which will be deposited here on this talus and that talus cliff create breakers. It will create breakers because this talus that means if the slope is not only it is ending here.

So it will continue up to somewhere here. So once it is continuing somewhere here that means this is the talus. So the wave will hit here and finally it will break. So once the wave breaks here that means this breaking wave becomes more furious and more effective for erosional process. So that means if it forms the submarine talus the base of the cliff to create breakers in the full energy of waves be impressed on this cliff.

So that its full energy is deduced here and some of this energy will be absorbed here and this will hit less at the vertical cliff. So to understand this process what is this marine system how the waves are attacking to this coastal cliff, how they are modifying the geomorphology along this coast. There was some experiment which was called wave tank experiment. Wave tank experiments in a laboratory there will be different scale.

When we are talking something about this geomorphological modeling you may remember. We were talking something about this dynamic model and static model. So this wave tank experiment it is in dynamic model. Here everything what is in the coast the analogous system is being developed on this laboratory, but with a suitable scale because we are preparing a model dynamic model.

That means we must have to consider the scale otherwise it will be useless. So with proper scale artificial coastal environment how they created and this wave were artificially generated and was interacted with this coast artificially generated coast.

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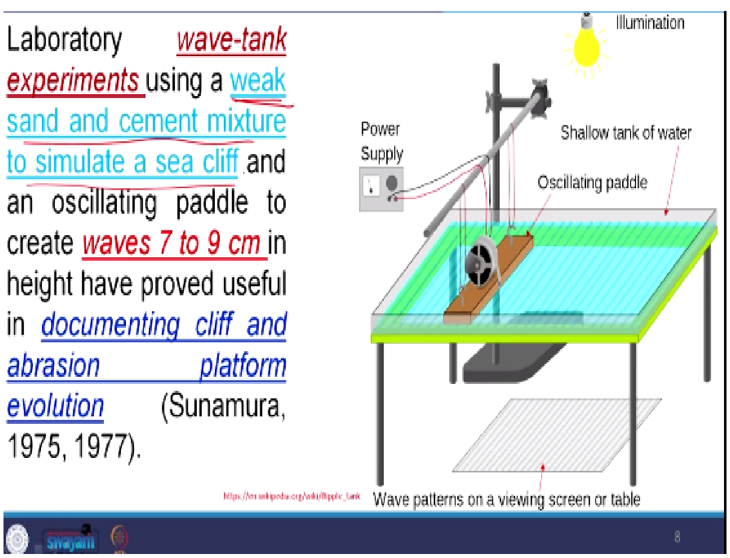

So that what is affecting it here, how the wave is interacting here that is explained here. This experiment was called wave tank experiment using a weak sand and cement mixture to stimulate the sea cliff weak sand and cement that our mixture is there and this is representing the coastal cliffs and on oscillating paddle to create a wave of 7 to 9 centimeter it is probably the representative of 7 to 9 meter.

In height that proved successful in documenting cliff and abrasion platform evolution. So that means this cement and sand mixture that was create analogous system of this cliff or this coast and 7 to 9 centimeter wave that were effective and how this sand or how this cement and sand mixture was eroded and how different landforms was created that has been explained here.

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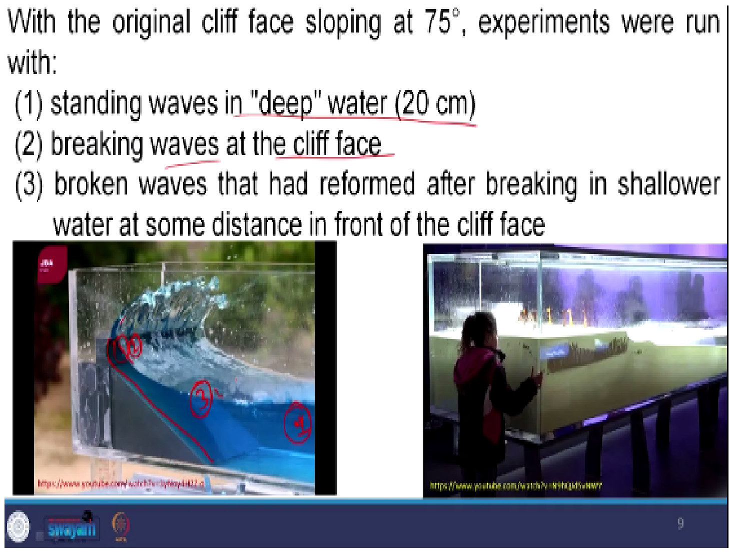

Now see with the original cliff face sloping about 75 degree experiments were run and there are 3 different conditions one condition was the standing wave in deep water 20 centimeter. So if we are creating a surface it is the coast if you see here this is the coastal platform and there is a standing wave in deep water 20 centimeter.

For example, here we are creating a standing wave in deep water. We are creating wave here breaking wave at the cliff face. So here you see the wave is breaking and one type of wave which is standing wave at 20 centimeter depth or about 20 meter depth in terms of real sense and another set of wave this is 2 here that means breaking wave at the cliff face this is number 1 and this is number 2.

And third is it is the broken wave that had reformed after breaking in shallower water at some distance in front of the cliff face. For example, here this is number 3 this is the broken wave that means here there is a barrier through this barrier this wave is broken apart and this broken wave is here and this is breaking wave is here and this is one is what is called the standing wave.

So 3 types of wave how they are interacting with the coast, how they are changing the coastal geomorphology. They are creating the platforms different types of geomorphic features that has been discussed here.

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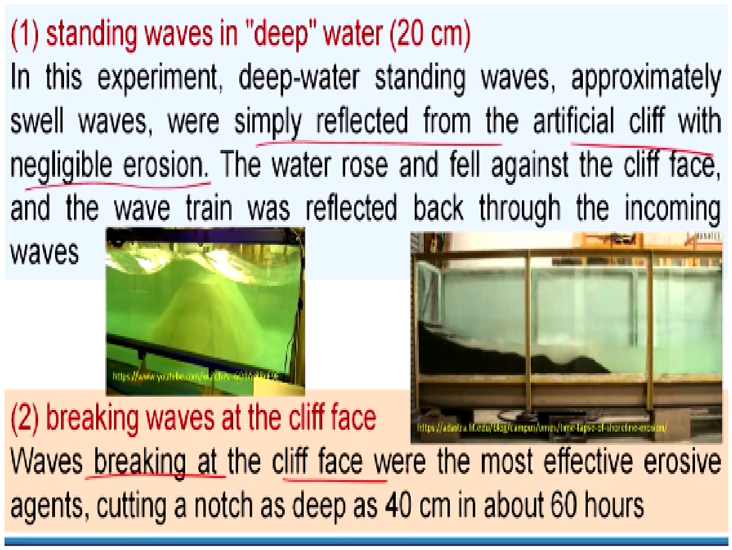

So in first case, first case means the standing wave in deep water 20 centimeter. So how this standing wave behaves. In this experiment deep water standing waves approximately swell waves were simply reflected from the artificial cliff with negligible erosion. Now you see the wave which generating just 20 centimeter or 20 meter depth or 20 centimeter depth here in case of this experiment.

They are simply reflected from the artificial cliff with negligible erosion. The water rose and fell against the cliff face and the wave train was reflected back through the incoming waves. So that means here if you see this wave were gone to the cliff face and it is reflected back again and some of them they are just like this water rose certain height and is fallen apart and this wave is reflecting back this is the first case.

In second case it is the breaking wave at the cliff face. Waves breaking at the cliff face where the most effective erosive agents cutting a notch at deep as 40 centimeter about 60 hours this is important here you see. So the breaking waves at the cliff face where the most effective erosive agents cutting a notch about deep of about 40 centimeter in 60 hours. So that means within the 60 hours those breaking waves they are more effective.

They eroded the coast, they created a notch wave cut platform or wave cut system. So that means material is removed here. So once the material is removed that means we are creating a notch that means the upper part becomes unstable and will fall down due to this free fall due to this mass wasting is not it. So that means the second type of wave which is breaking at the coast, breaking at the cliff they are more prone to erode the coastal platform, more prone to erode the coastal cliff.

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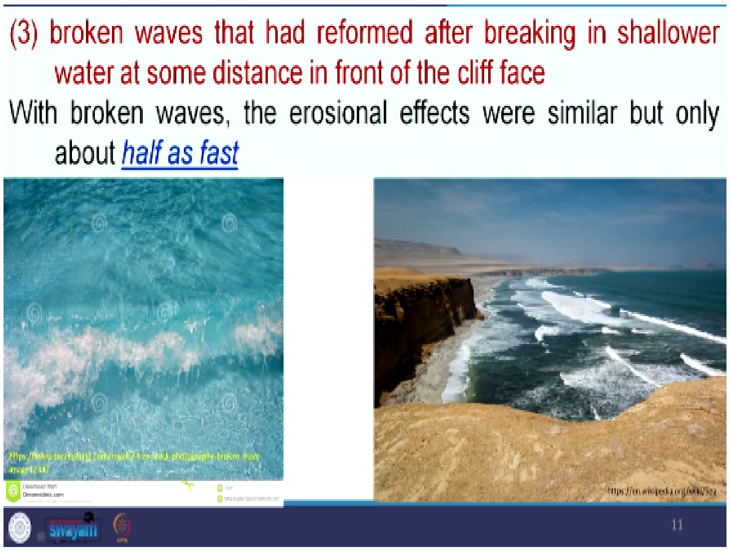

And the third one the broken wave that had reformed after breaking in shallower water at some distance in front of the cliff face. So that result is with broken waves the erosional effect were similar but only half as fast. So it was in 60 hours we created a 40 centimeter deep notches, but this third type of wave which was already broken in front of this cliff somehow distance in front of this cliff.

That waves though they are eroding, but it is effectiveness the rate of weathering is half as compared to the breaking wave. So that means out of the 3 types of wave the breaking waves that means those waves which are breaking at the cliff face they are more prone to whether the system, more prone of whether the cliff as compared to the other 2 waves. So the first one is ineffective, the second one the breaking waves that is more effective.

And the third one the broken wave that is effective, but as half as compared to this breaking waves. So this 3 types of wave though are there the second and third type of wave they are more prone to generate sediment, they are more prone to erode this coastal cliff, so they are more prone to handle this coastal geomorphic system as compared to the first one.

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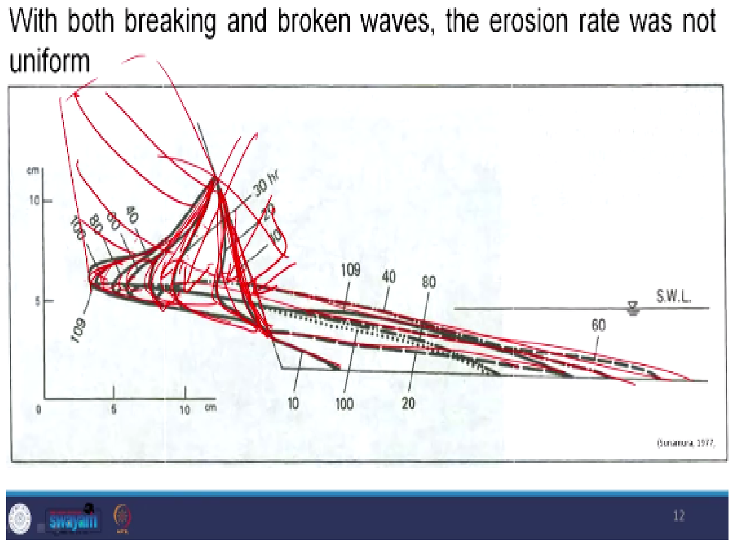

With both breaking and broken waves the erosion rate was not uniform. Again this breaking wave is there, broken wave is there, but this erosional system the rate of erosion was not uniform. For example, if you see this figure here this is within 10 hours we are getting this much erosion within 20 hours we are getting this much, within 30 hours we are getting similarly 40 hours, 50 hours, 60 hours and 800.

That means if you see at first the erosion is along this face and the second, third and progressive once time increases we are creating a notch. So that means if we are creating a notch like this, this part of this cliff this becomes unstable. So that means due to mass wasting this part will finally fall down. So once this part falls down what will be there. So this wave has to redistribute the sediment. So this redistribution of the sediment they occur here.

Now you see at the first case we are creating a platform like this. In second this eroded sediment will be distributed here, the third case this eroded sediment will be distributed up to this, fourth case this is this. So that means more and more landward we are eroding, more and more we are creating a platform like this depositional platform like this. So that means erosion and deposition they are going on simultaneously.

And creating a balanced platform along this coast. So if the coastal retreat is uniform it is moving uniformly towards this coast, towards the land that is called an equilibrium coast or otherwise it will be called disequilibrium coast. So if you see here at the initial slow erosion feed sand grains from this weak sand and the weak cement which that becomes abrasional tool for an internal of accelerated erosion.

For example, if you see initial stage when the wave hit this cliff. So that means it will effect this cliff only. So imagine this water does not contain any erosive material like the sand particles. So continuous erosion of this cliff so it will remove the material from this cliff itself. So that removal of this material that means now we have water as well as the material with that.

So that means the abrasive power of this water is increased. So once the abrasive power increases that means the rate of erosion increases. For example, if you see here this first case the rate of erosion it is only this much volume of the material is removed. In the second case this much volume of the material is removed, in third case this much volume of the material is removed and in fourth case this much volume of this material is removed.

So that means if you see in first case the rate of erosion is slow, in the second case it is more, in a third case it is again more and the fourth if you are moving to fourth case again it is getting lesser and lesser. Why it is happening so because at the initial time we have only water so rate of erosion will be less. In the more and more hitting to this cliff more and more sand particles we are removing.

So now we have water as well as sand particle mixed together. So together we are hitting the system so more erosion and third case more erosion and in the fourth case what is happening when number of sand grains, number of sand particles become more so that means much availability of sand will be there. So this energy of this wave is absorbed by the sand particles.

So once the energy is absorbed by the sand particles those wave becomes less effective to erode. So that again the erosion rate of erosion decreases. So that means initial stage the rate of erosion will be less, in the last stage or the later stage less of erosion will be rate of erosion will be less, but in the middle stage the rate of erosion will be more. So this is all about your coastal retreat and this wave cliff or the cliff retreat and this wave action along this cliff and I think we should stop here and we will meet in the next class. Thank you.