Maintenance and Repair of Concrete Structures
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Lecture – 24
Waterproofing of Concrete Structures

Hi, in this lecture, we are going to cover waterproofing of concrete structures and there are 2 lectures in this module, this first module we will look at basic principles.

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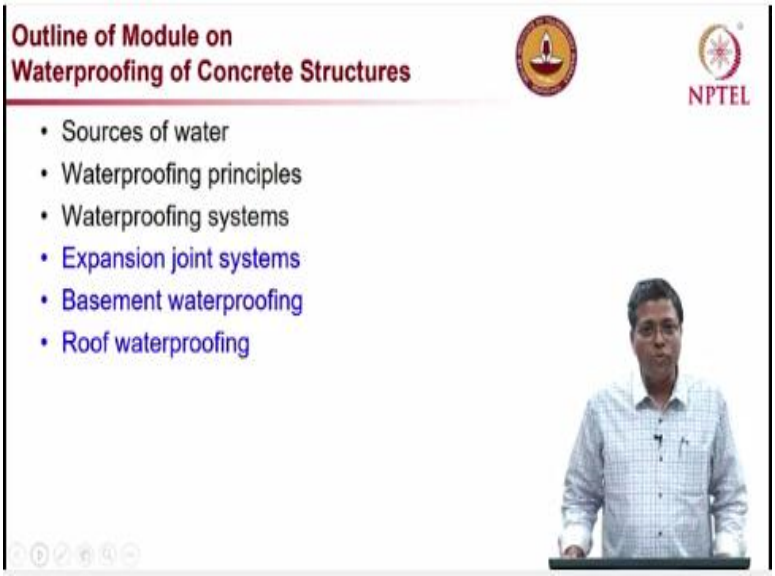

This is the outline for this module on waterproofing. In the first lecture we will look at sources of water, waterproofing principles and some general idea about different waterproofing systems and in the next lecture, we will look at especially on expansion joint systems and basement waterproofing systems and systems for roof waterproofing.

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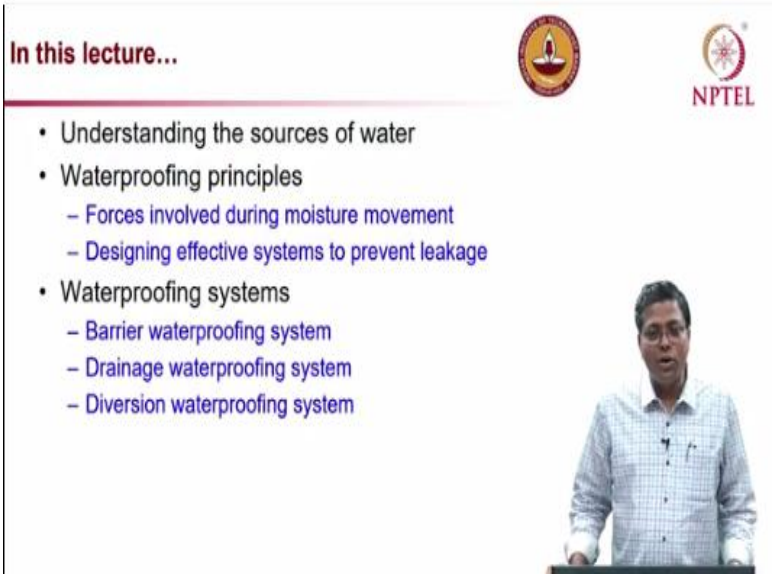

Now, in this lecture I just want to tell what we are going to discuss in today's lecture. It is, understanding the sources of water. Where the water is coming from? And then water proofing principles, mainly looking at the forces that are involved in the movement of water and also how to design effective systems to prevent leakage. We will talk about 3 major types of water proofing systems. One is barrier waterproofing system and then it is drainage waterproofing system and then we will look at diversion waterproofing system.

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So, before getting into all that details, let us look at the different demonstrations of dampness in building elements and based on which we know what the source. So in these pictures which I am going to show in next few slides, I will also talk about where the water is coming from. So it will be easy for you to detect the source of water, if you see a particular type of damage or manifestation of moisture damage.

So, the first picture blistering of paints at the corner of the walls, you can see here on the picture on the left, the paint is completely getting damaged. Definitely, it is because of moisture inside the wall and then that moisture might be coming from either a concealed pipe or from the floor because of the capillary action and you can see in most of these type of buildings, you will see that this kind of damage is very prevalent in the space like in the surface which is about 1 meter or 2 meter from the ground level.

If that is the case, it indicates that it is actually due to the capillary suction or the water which is available at ground and that is being getting into the wall element or the concrete element we are talking about. Picture on the right side also very clearly shows this. So here you can say that this is from ground but maybe this portion on the top right that is definitely not from ground.

But you can also see the direction of the movement like you can see water is moving something like this looking at the structure of the stains or the shape of the different stains on the wall surface, so the top right that is because of water coming from the floor above it. Mostly it is because of either a bathroom or some pipeline which is going and which is corroded probably or water leaking from the concealed pipes.

Or whatever be the source, even it could be just a roof element above rain water get stagnated around the corners and then it seep into the walls and then it is manifested as it's shown on the top right corner of the picture and here also you can see a lot of dampness along the joint between the wall and the roof and also on the corner. So, when you see something like this, you can actually go to the other side of the building and see if there is any other side of the element and then see if there is any indication of source of water on the other side.

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This is again, couple of additional pictures where on the left side you can see drainage ducts from the restrooms and toilets. This is a three storey building, you can see a lot of pipelines coming out from the walls around and the entire shaft is really wet and you can also see that wetness leading to corrosion of the rebars. So this is not definitely a good thing to happen.

And also if you look carefully on this paint, it's all blistered, paints are peeling off because of the pressure due to the presence of water inside the wall element and it just de-bonds the paint from the plaster and here you can see again inside a bathroom. Definitely, it is because of the water leakage from the concealed pipes and here probably, it is because of either the roof element. You have to see in these cases, what is on the other side of the element, so that you can really decide on what is the root cause of the problem.

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And here it is a photograph showing dampness, here you can see in this portion here and in this particular case, there was actually like poor quality mortar and also the ground on the other side it is a basement region and here on the ground you have water stagnation and somehow that water is getting into it and also there were concealed pipes; possibility of concealed pipes in this as I draw there.

And because of all this, so to understand where is the water coming from; first you look at how the damage looks like or the pattern of the damage and then look at what is available near so that what is the source of water, it is very important and sometimes it might be pipes, sometimes it might be stagnant water and sometimes it might be just the water from the ground.

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Now, here another example on the rooftop; this is very common in the rooftop, you can see especially on high rise building, apartment, complexes etc., where most often the terraces are locked, so people don't go there and check what is the structural condition? So condition could be sometimes something like this, because we don't have a proper inspection practices, so we allow the grass and small plants to grow there and which is not good.

And also you can see in this picture on the right side, you have a lot of dirt accumulation also, so that when you have soil there that actually keeps the moisture and then it keeps supplying the moisture to the concrete below, which will eventually lead to cracking etc., Now, I want to mention here on the photograph on the left side, you can see again lot of plant growth below and in between that pipes.

But this crack is not due to water proofing issue but it is mainly due to the pipes which are corroding as you see on the leftmost side, this particular pipe has corroded and similarly, all these pipes are probably corroding inside that mortar and that is actually causing expansion and then leading to the cracking of that mortar.

So, all this we need to look at and then if something like this is happening, we should attack immediately and prevent that problem before letting the pipe corrode completely and which will end up in replacement of the whole pipe, which is much more expensive than removing some of these bricks and then relaying that and preventing that. Do proper anti-corrosion treatments and then prevent the corrosion or stop corrosion from happening.

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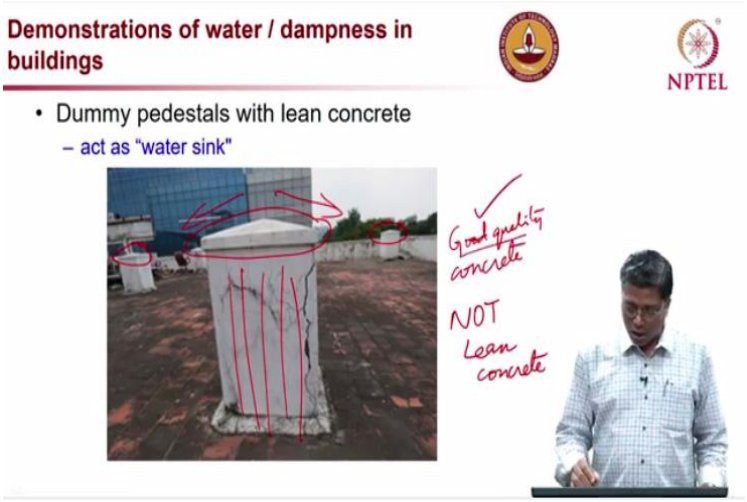

Now, let us look at another problem which we often see. This is a typical pedestal which we will often see on most of the roofs which are like on maybe 2 or 3 floor storey buildings where in anticipation of going for another floor, people provide these pedestals, something like this. You can see here this pedestal; there is essentially extended rebars inside.

And the cracked concrete which you see is actually lean concrete; they put that lean concrete because they want to use the rebars inside to continue as the rebars for the next column on the additional floor which might come up. However what is happening is because it is a lean concrete, they end up in functioning like a water sink.

So, it absorbs all the water and keep the water there and that allows the corrosion to happen and so eventually, when we really want to use this rebar coming from the columns below, when we want to use them they are most often found to be heavily corroded and we end up in cutting it and then actually going for anchors to the columns below.

So, if we go for this, please go for good quality concrete, not lean concrete that is the message which I would like to give here and also one good thing about this particular pedestal is they are provided a little slope, so that water will move away from the surface. If you have a flat surface, then what will happen is water will stay on there.

Then water gets absorbed by the concrete faster which is also not good, so go for good quality concrete and not lean concrete. So this is what we should use for all these pedestals which we are talking about, don't use lean concrete.

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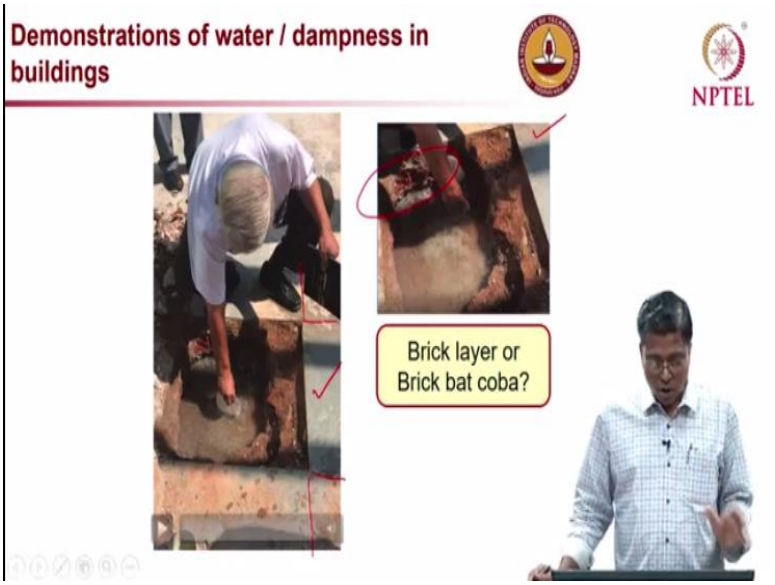

Now, another demonstration of huge quantity of water can be actually stored on the roof top especially when there is brick bat coba or a brick layer. So you see the picture on the top right, where you can see a brick here. Typically nowadays instead of going for a jelly brick bat and jelly and then mixing it with lime and all that. Nowadays, people are just laying the bricks and then providing the tiles on top.

So, as you can see here, this is a cota tile here and so I am going to show you this video to show you that how significant this problem can be and this video was taken just 1 day after a rain. So what happened is all these joints between the tiles as you can see here, all these joints between the tiles they were not so good, so water actually infiltrated through that.

You can see very clearly in these joints there is no gap in between there is no other filler material between the tiles. So whenever you lay a tile you should make sure that there is enough filler material, let's say typically 5 millimetre gap and then in which you fill other material, so that it seals properly or you can have good pointing if possible.

So, in this particular image or video you will notice that there is no gap which is not a good practice to follow, unless you have another set up for preventing the entry of water into the brick layer below.

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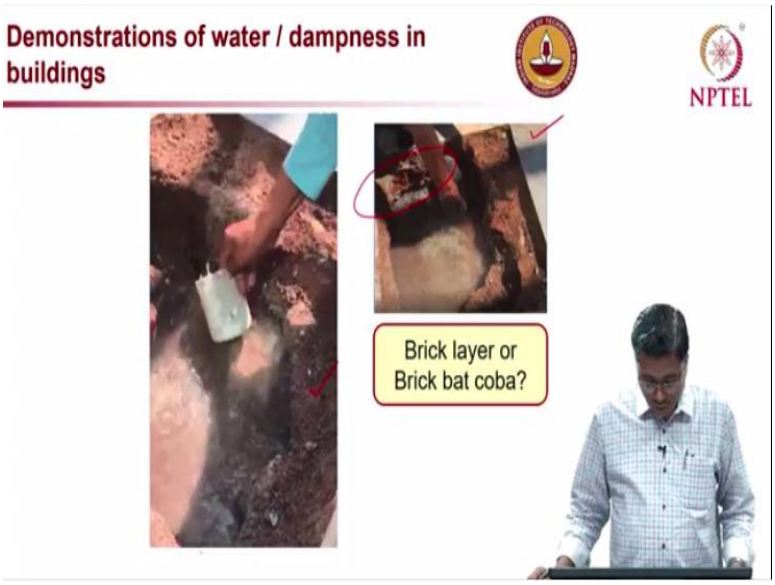

So, let us watch this video and you will see that. Water is gushing into this space as we remove the water, more and more water is coming in. So all these water is stored on this rooftop.

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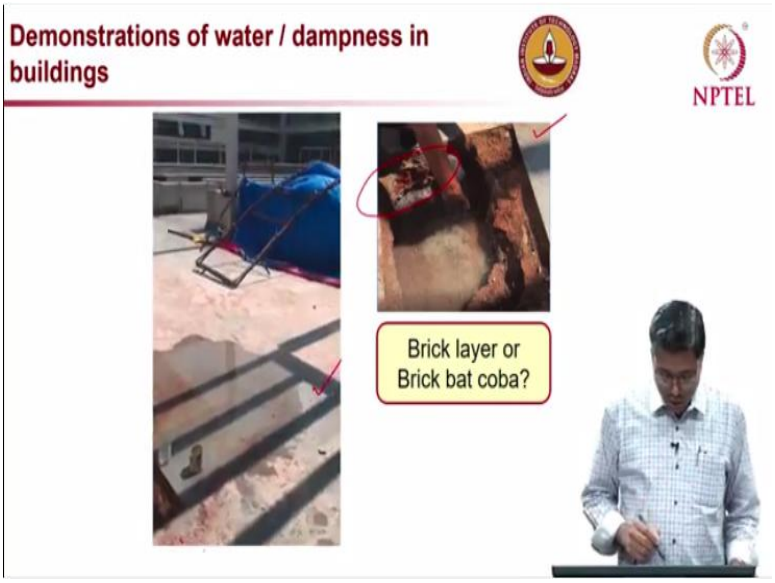

You can see here, so which is not at all a good thing to happen.

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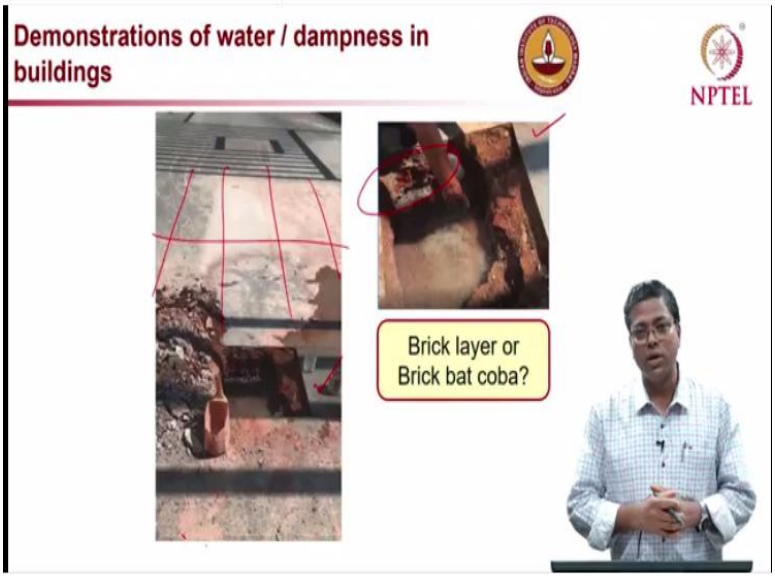

So, we must make sure that all these joints are very well protected and they are watertight otherwise, this huge amount of water can stagnate on the rooftop and then that water will provide sufficient moisture for the reinforced concrete slab or the roof below which will then lead to accelerated corrosion.

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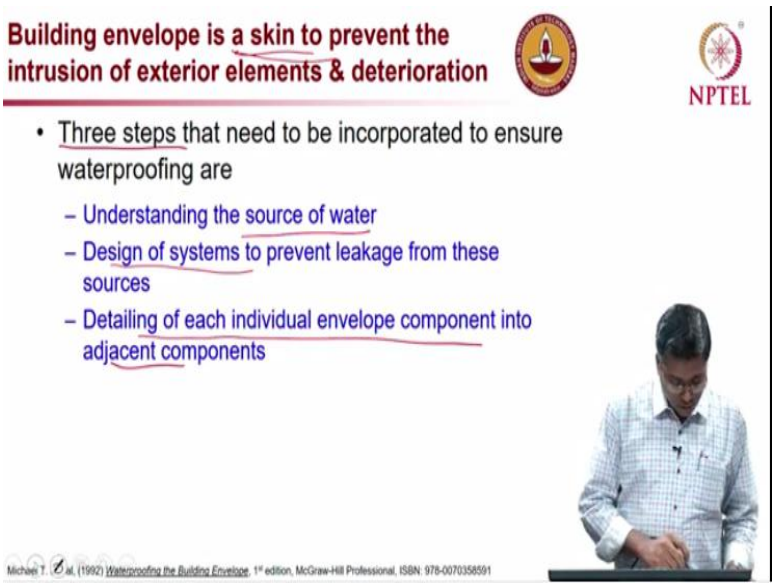

Now, building envelope; so I have just shown you all different source of water or how water can affect the buildings. Now let us see how to prevent the intrusion of water into the building. So, building envelope is a skin to prevent the intrusion of water into exterior elements and prevent deterioration. In this aspect we are talking about intrusion of water.

So, 3 steps that need to be incorporated to ensure waterproofing are, understanding the source of water, we already discussed that a little bit. Now, we have to design a system to

prevent the leakage from these sources that is to stop it at the source and then also detailing of each individual envelope component into the adjacent components. So, the detailing is very important.

Whenever we talk about waterproofing, the detailing is very important. For example, if you want to create a waterproofing layer and maybe the material is very good, the system is very good but if the joints are not good, it is going to fail or if there is a small scratch on a sheet or water proofing membrane that water will penetrate through that scratch or crack.

So, such things must be checked before we approve the work because this detailing is very important.

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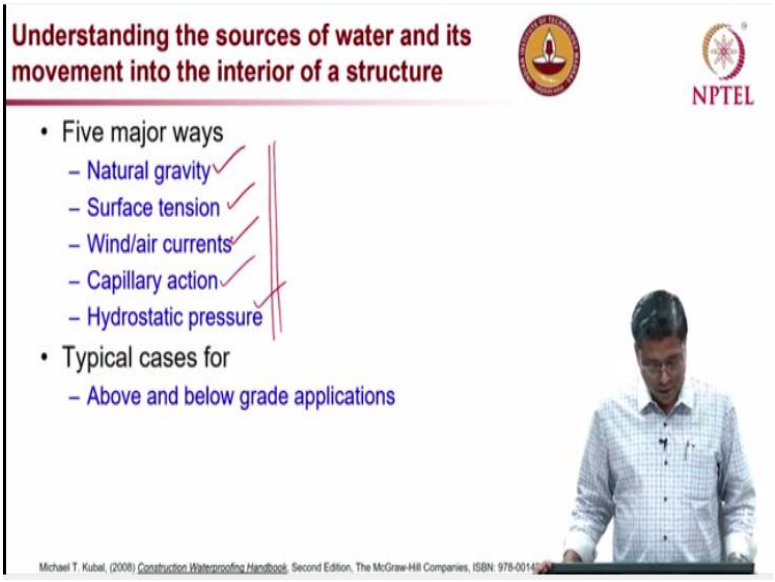

Now, before talking further on those detailing and then different systems, let us look at how to understand the sources of water and its movement into the interior of the structure. So, first 5 major ways by which the water can enter a building or a structure is, one by gravity and then because of surface tension of the water and then because of the wind or air current Let us say you have a heavy wind and there is rain, the water will splash onto the building surface that is this.

Also capillary action especially from the ground; the water on the ground level can rise into the building and also hydrostatic pressure. So all these are the 5 typical ways by which water can enter building elements and we will talk about one by one.

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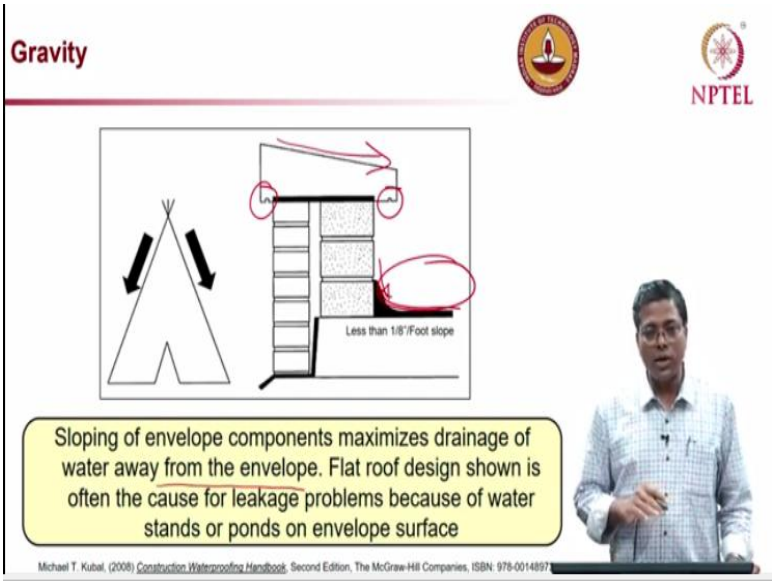

So, this is gravity, the picture on the left side is a typical roof structure where the arrows are indicating the downward direction indicating that water will flow like that. So, typically on the roof we provide like this, so that water will get out of the roof as fast as possible. So, steeper the roof, water is going to flow faster. On the right side also, it is just, Coping on a building you can see that here that slope will help the water to drop faster.

And what will happen here and here we will talk later in the coming slides and also here you can see when water is there, we want to drive out the water early. So downward direction we have to let it flow. Now, sloping of envelope components maximize the drainage of water away from the envelope and flat roof design shown is often the cause for leakage problems.

Water stands or ponds on the envelope, so this is the portion that we were talking about, the flat roof. So, if the slope is not enough then water will stay there and eventually it will somehow get into the roof elements and all that. So we must provide adequate slope on the flat roof buildings and also at the same time, not only providing slope but also drainage; the holes which we provide at the drainage pipes that should also be larger. Sometimes we see good slope is provided, the pipe is so small that even a small leaf will just clog that thing.

So, it's always a good practice if we can have a cleaning up of all the leaves, dirt etc., before the rainy season comes in, so during the end of the summer season itself we should actually remove and keep the roof neat and clean without any leaf and dirt.

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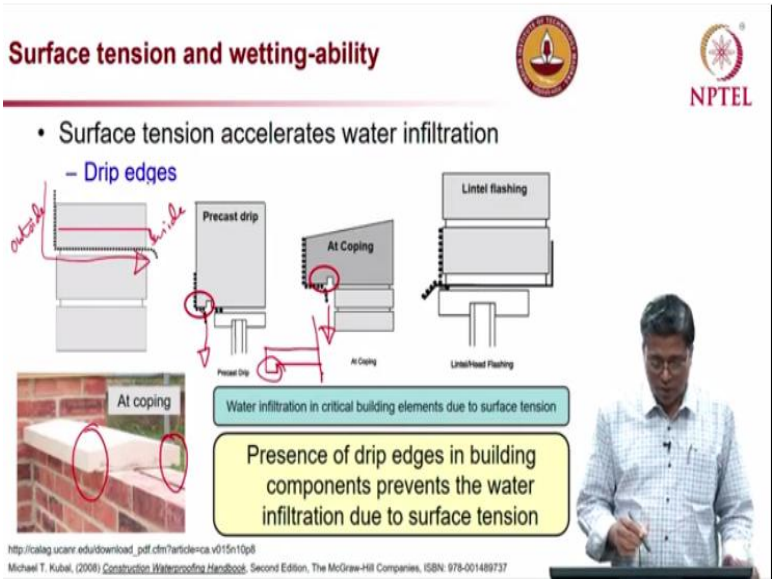

Now, other mechanism by which water enters is surface tension and the wetting ability of the water mainly the surface tension. So, surface tension accelerates the water infiltration, so like this as you see here on the left side, water can come in, if this is outside and then water can come into the inside, so that is not something that we want. So, in this case we can provide this kind of drip edges as you see on the second and third images which will help the water to just come down like this instead of going into the structure.

And this is similar thing shown here on the picture on the bottom left. You can see a small drip edges created and also you will see these kinds of things on many of the sun shades in our construction, you will see that sun shades we have something like this. If I draw sunshades you will see something like this at the edge of the sunshade which will allow the water to just drop down instead of getting and flowing like this.

So that won't allow that to happen. Now, lintel flashing or some kind of systems where you can see here it is coming all the way something like this. So that water comes this way and then just flows and it does not allow the water to enter the building. So, presence of drip edges in building component prevents the water infiltration due to surface tension.

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And this is again couple of examples to show you and then make things clear to you, you can see here on the picture on the left side, there is an element which goes something like this. So this prevents the water from entering into the brick masonry or even into the top of this concrete lintel beam, this is the concrete lintel. So, the water just flows down and then over here it turns left and then turns outward.

So, similar examples on many buildings you can see here because these window regions have lot of metallic elements which need to be protected from water. So we just provide these flashing, so that water just comes out, it does not get into the window region. So, presence of drip edges in lintels prevents the water infiltration due to the surface tension.

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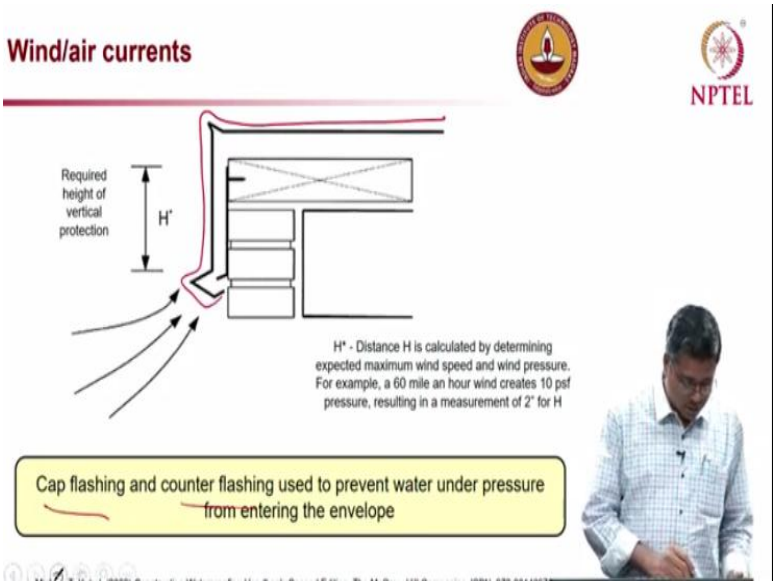

Now, wind and air currents; so here a little bit of pressure is also involved because the water just hit on the building elements and it is not just capillary suction or anything but that pressure, the speed at which the water is hitting that can also create faster infiltration into the building. So to prevent such things what we usually do is you provide an additional element like this, which really creates a good protection against the water.

So, cap flashing and counter flashing used to prevent water under pressure from envelope. So here we are mainly talking about water falling onto the building elements with high pressure.

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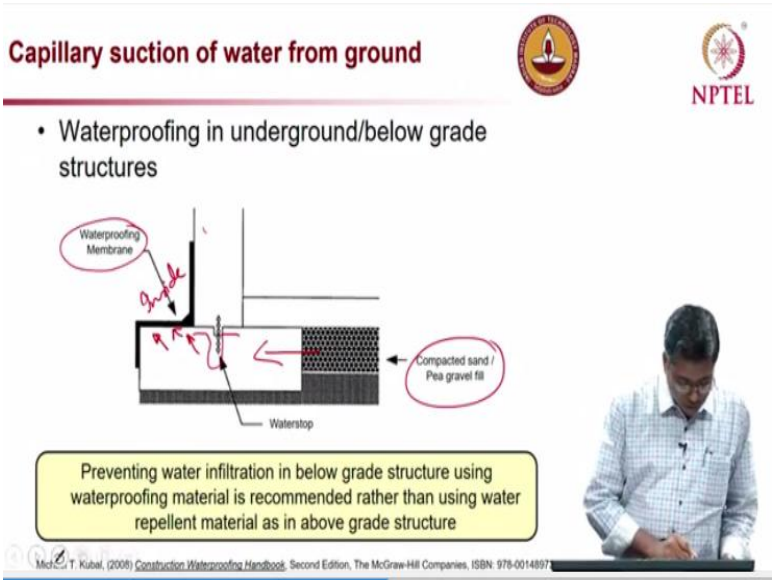

Now capillary suction very common problem in most of the buildings when we talk about especially the ground floor. So, here you can see compacted sand or gravel fill and then

2 systems which you are seeing, one is waterproofing membrane, the other one is water stop. So, water can actually enter if these elements are really porous in nature, if the capillary pores are existing, then water will easily flow like this and enter the building.

So, this water stop actually prevents the water, so if water has to go into the building it has to go like this, so it just kind of creates an extended path or a longer path for the water to flow and that is the main idea of providing this water stop and then they help in preventing the ingress and also even if for some reason water reaches on the right side of this black membrane shown, the membrane will help it to get into the inside of the room. If this is the inside, so water just comes here and then it cannot really cross that membrane, so it just stops here. So, that is how the waterproofing membrane works.

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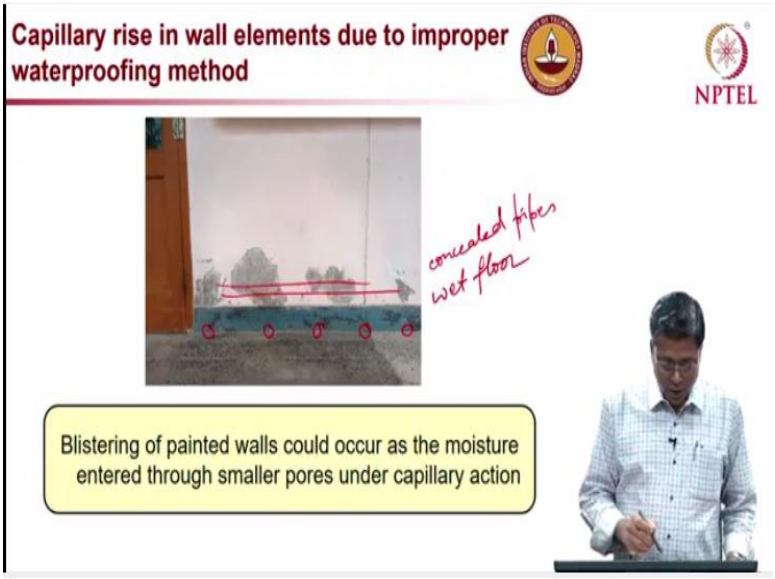

But also there are other ways instead of providing a layer, there are also ways by which this particular thing here you can see some injections which we do. Basically, idea here is to reduce the amount of capillary pores available and then you inject some chemical into the wall which will fill the pore space available. So, that stops the entry of water from.

So, here in this particular case there is actually a concealed pipe which goes like this and which is leaking and also the floor behind this wall is actually a restroom. Concealed pipes and the wet floor, 2 things are here. So, in such cases one is if the floor is wet, capillary suction might happen, if the concealed pipe is there which is corroded or somehow water is there that is also another problem.

And if there is pressure then that is also another problem, so in whatever way if we can reduce the pores available in the wall, then that will probably help to prevent this water damage.

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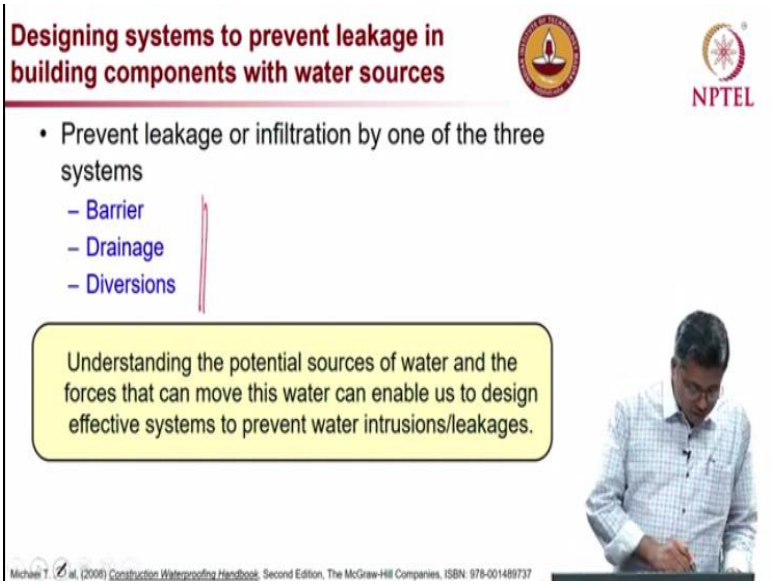

Now, let us look at how to design this waterproofing systems, so designing to prevent leakage in 3 ways; one is by going for a barrier system, the second is by designing a drainage system and third is by diverting the flow of water. So, understanding the potential sources of water and the forces that can move this water can enable us to design efficient system.

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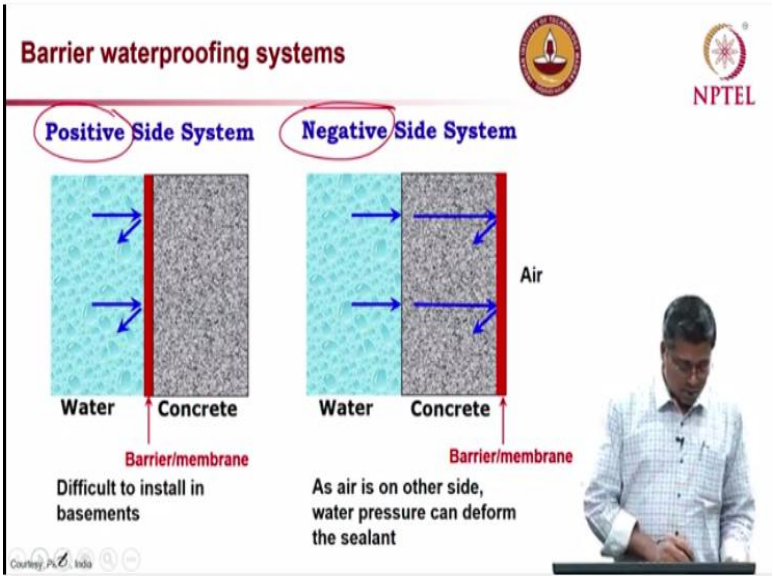

So, let us look at the barrier proofing systems first. So there are 2 types of barrier proofing system, one is positive side barrier proofing and the negative side barrier proofing. Positive side means it is basically, the barrier which is the red coloured barrier on the

photograph on the sketch, the red colour barrier which is in between the water and in between the water or soil containing water and the concrete on the right side.

So, what happens is when there is a pressure from the water body onto the barrier that actually rests on the concrete and it does not lead to peeling off of the membrane because the membrane is experiencing a pressure from the left side and it is resting on to the concrete on the right side. So it cannot really get peeled off but as on the negative side system, which is on the right side you can see that barrier is actually on one end, on the right end.

Let us say the concrete allows the entry of the water, so eventually it exerts a pressure on the barrier and then barrier could get peeled off or blistering which we usually call, so that it can fail relatively easily, unless the concrete itself is treated very well and as the barrier is functioning like a secondary system or unless you have a very good bond between the concrete and the barrier system. So, there are ways to go around it but typically, you have to see if possible, it is always better to go with positive side barrier system.

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And this is some examples or sketches I just wanted to show you how the membranes can peel off from the concrete surface. On the bottom left, you can see uneven surface, water can actually come and collect also in that uneven that blue region is indicating the water and then it can eventually lead to the failure of the membrane.

Because once water gets collected like this, then the membrane is no more in proper bond with the concrete, so it might eventually fail. Now, also here you can see, again this

membrane getting disconnected from the concrete, so this is like if you have some other, dirt or something if the surface is not very well cleaned then again you can see this peeling off.

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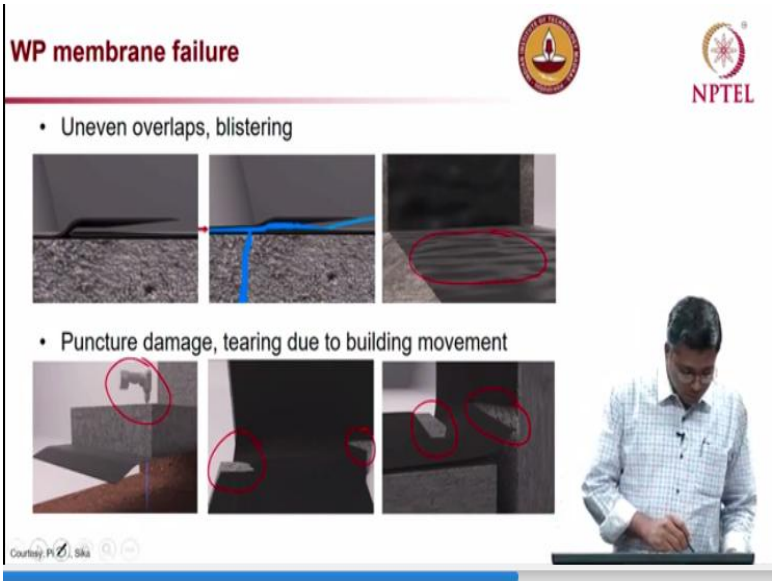

So, you have to look at the different cases and then how this peeling off can happen and then if you see that peeling off is happening, then we can really look at how to prevent them and here are some more examples where uneven overlaps of this membranes. This is all coming to the detailing of the systems, unless you detail them properly, you will not be able to do a good job.

So, you can see lot of blistering on the right side, uneven surface that is also indicating that where there is no bond between that element and the concrete. So, if this is actually a negative waterproofing system, then it is not really going to last that long and also you can have during the construction, people can use some tools like drills and all that it can puncture.

So, when we talk about waterproofing membranes, it has to be a full proof, 100% no damage, otherwise wherever there is a small damage that will lead to the entry of moisture and then it will get into the space between the concrete and the membrane and then it will delaminate leading to a delamination and then eventually, the system will not function as expected and also if there are movements of concrete elements; adjacent elements it can lead to tearing of the membranes as you see in the pictures here at the bottom right.

So, nowadays there are membranes which come with very good elongation before they actually tear. So many membranes are also good but you have to see, do we need to spend a lot of money in going for such materials or systems or can we have such materials just at the joints alone, so that you can optimize on the cost of the repair work.

Because if you want very high elongation only provide where it is required, so the engineer at site has to decide that. If there is a joint and there is a possibility of significant movements, let me put a material which will have very good elongation only in that region because as you asked for this kind of material, the cost is also going to go high. So you can use this kind of materials with high elongation only for the joint system and then remaining regions can be with some other material and then provide proper joint glue between the 2 systems.

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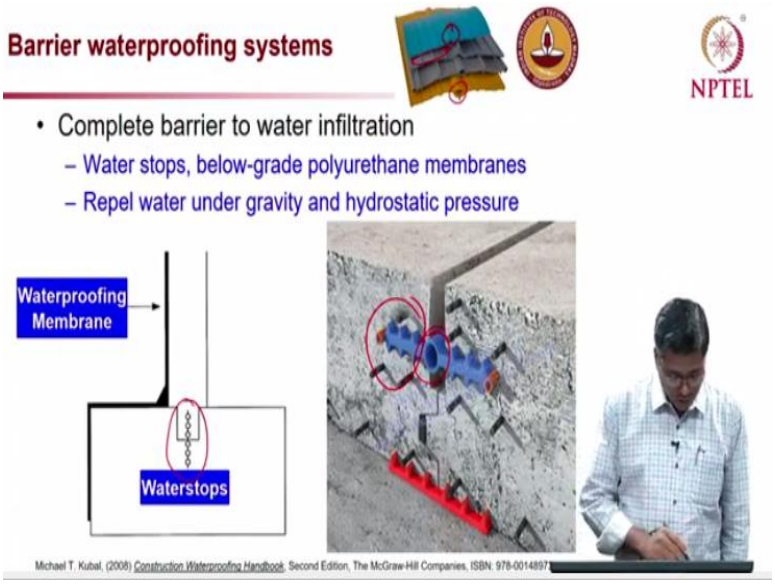

And also water stops are something which are becoming more and more popular, as you see on the photograph on the top right, you can see different type of water stops, this has a bulb there, this one is slightly larger and a lot of ribs, so we will show you some photographs, so you can see here ribs and then bulbs there. So these are different type of water stops available which will help prevent.

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These are examples of water stops on a site, we can see here different types one of it is put all around, all along the periphery, so that you can stop, especially used for retaining walls or elevator shafts all that where we can really stop the entry of moisture.

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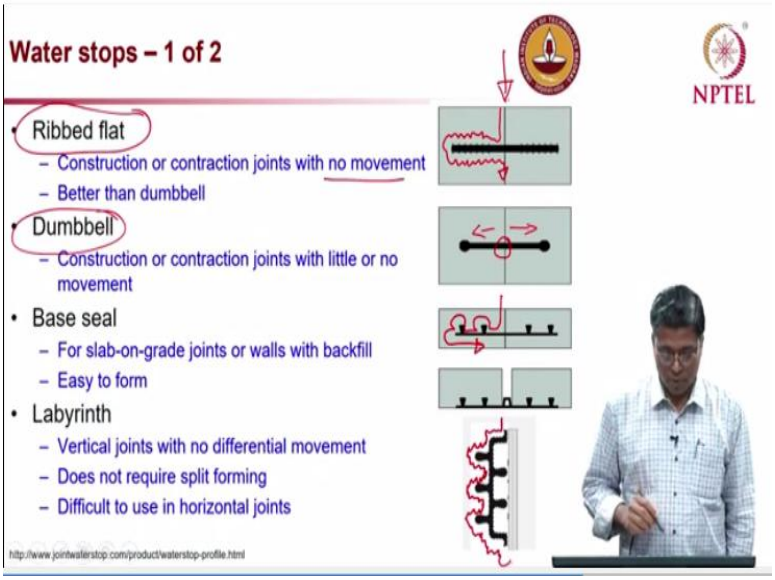

Now, examples of water stops; we can see here on the top right the ribs, so that is ribbed flat and let us look at where they can be used; when there is no movement between the joints as you see in this picture there is no, it is just one line which shows the joint. There is no gap. So, when there are joints which are not supposed to move in that case, you can use this kind of ribbed flat or dumbbell.

Because again, if there is movement like this, then this is going to elongate this region and that material should be good enough to resist that elongation or it should have good

elongation before it can tear. So these are also labyrinth you can see here, how long. Let me take this example of the first image here, if water is getting in through this, the idea here is the water should come like this, it has to go through all along and then go like this then only it will reach the bottom.

And this extended path for the water that will itself stop the water from entering, so it will be very difficult for water to go from one side to the other, in this drawing which I showed from top to bottom, it will be very difficult, so it stops the water. Same principle applied in all the drawings. So all the different models, as you can see here the water has to come like this, go like this, go like this then only it can reach the bottom.

So, the length of the path is increased in this case, in the labyrinth one, there is much more because actual length of the path will be much higher, much longer.

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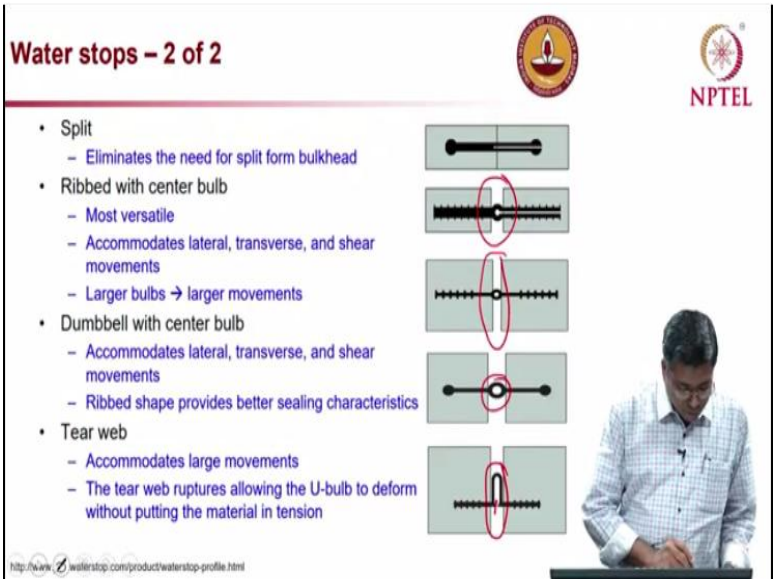

Now, another set of systems which can be used for systems where movements are also allowed. So here for example we can see here bulb, this is similar to the photograph I showed in couple of slides earlier, we can see bulbs here and this one especially, it is very good when you have large movements possible. So what happens is if there is a potential large movement, so the larger the bulb size, it allows more movement.

So, here this will just tear and that will give really good protection against the entry of water, so this kind of water stops are very good and they can be used for new construction.

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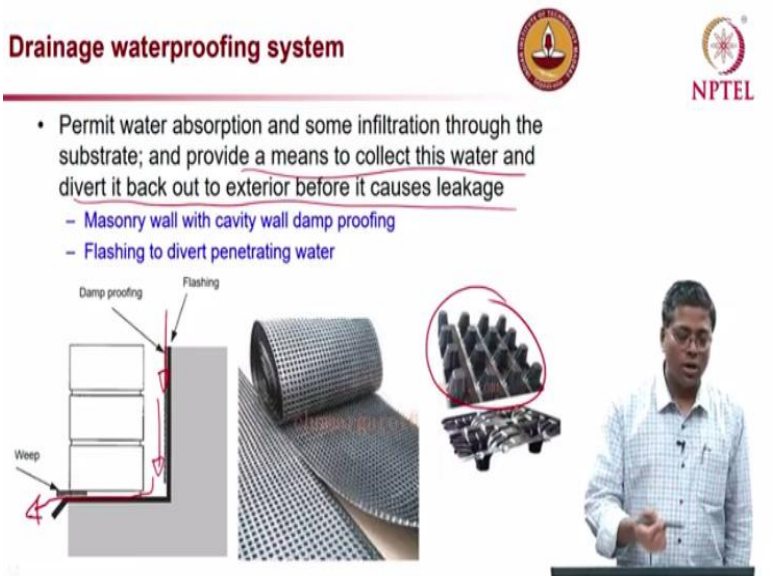

Now, other thing which we want to look at is drainage water proofing system and so here, the main idea is allow the water to drain through some predefined locations and then collect that water and then take it away, so you can see here this drain boards which looks something like this or it comes typically in rolls and the idea here is you have water which can flow like this.

And in this case, you can just take it out of a weep hole which is provided. So it permits the water absorption and some infiltration through the substrate and provides a means to collect this water and divert it back to the exterior before it causes leakage or before it enters the building.

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It is an example where drain boards have been used. First look at the top right image where you can see the building standing there and then they are actually protecting the wall below, so now let us look at the picture on the top left, we can see the drain board being provided and also you can see these water collection points PVC pipes at the bottom.

And these PVC pipes are taken into the trench on the right side, so this is the trench. These are the trenches and you can see, this PVC pipe showing up there and then from that trench, another pipe will be going right. You can see on the picture on the right side, so these trenches are then filled with aggregates, so that you have enough air space for the water to flow at the same time, it takes all the mechanical loads.

And then finally, it is shotcreted that is you see on the bottom left photograph shotcreted and then covered and then everything is set inside. So inside like what we showed in the previous one, there is a pathway like this or a drain board is installed and then covered with shotcrete. So, if there is any water coming it will just flow through the drain board which is kept inside the shotcrete or in between the soil and the shotcrete regions.

Now, drain board installation around the building envelope ensure proper collection of water and drain it away, so it is like controlling the way the water flows.

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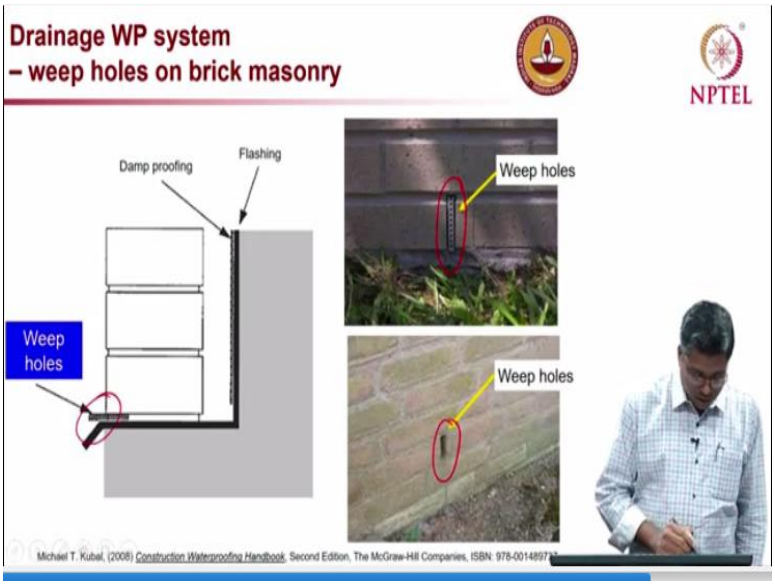

Now, for weep holes that these are examples of weep holes which we showed as you can see here.

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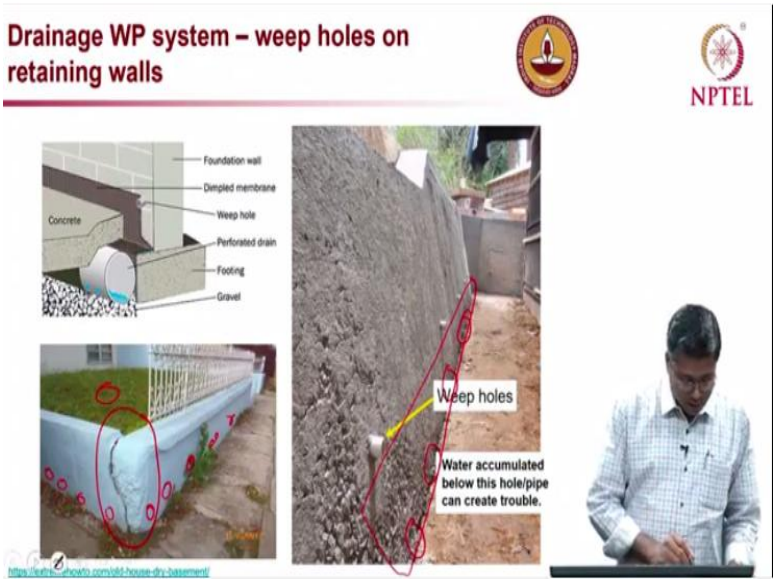

And one more photograph I will show about this weep holes. Look at this weep holes, what about this? If there is water collected below the weep holes, so this what you see on the right side is not a good system, weep holes should be provided always at the bottom. I am not saying not to provide in between but there must be a set of weep holes at the lower most points, so that no water is staying or getting collected and generating hydrostatic pressure.

So, we must provide weep holes at the lower most points also. Now, just to tell something that can actually happen, here what you see is this is cracking over here. So this

crack is probably due to the presence of the hydrostatic pressure or maybe because the soil here is swelling, when water gets in or maybe whatever be the root cause.

So, if we are providing weep holes, probably this problem will not happen, this cracking will not happen. I am eliminating the fact that there may be a discontinuity in this or the brickwork may not be properly done but assuming that all that is proper and just to show how important the weep holes are. So when we do something like this please provide some weep holes like this so that whatever moisture is there, it will come out and it will not allow that hydrostatic pressure to generate which will lead to the cracking.

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Now, these are good examples showing how the weep hole should be installed, here you can see there is one set at a higher level and one set of weep holes at the lower most level also, so this is very important, providing weep holes at the lower most level is very important and here also you can see there are weep holes provided at different levels and also at the lower most level.

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Now, diversion waterproofing system is similar to what we just discussed but here we have again a different type of system. So, it redirects the water forced against envelope components and divert it elsewhere, you take the water away. So here you can see if this is the moist soil here, there is a possibility of water getting in and eventually getting into the interior of the building or the rooms which we want to protect.

So, let us see how it is being protected. So if the water is coming in, so there is a space between this and the concrete wall, so somehow water will drain through this drain board and then it will get into here and then into this French drain and then the water will flow along the drain like this. So this is the French drain here, so water is collected somehow because of the drain boards; the black thing on the screen is a drain board.

So that collects the water and then drives or diverts the water into the French drain which is provided below and kept on gravel because again you do not want soil there because you want air space, so that water can flow through.

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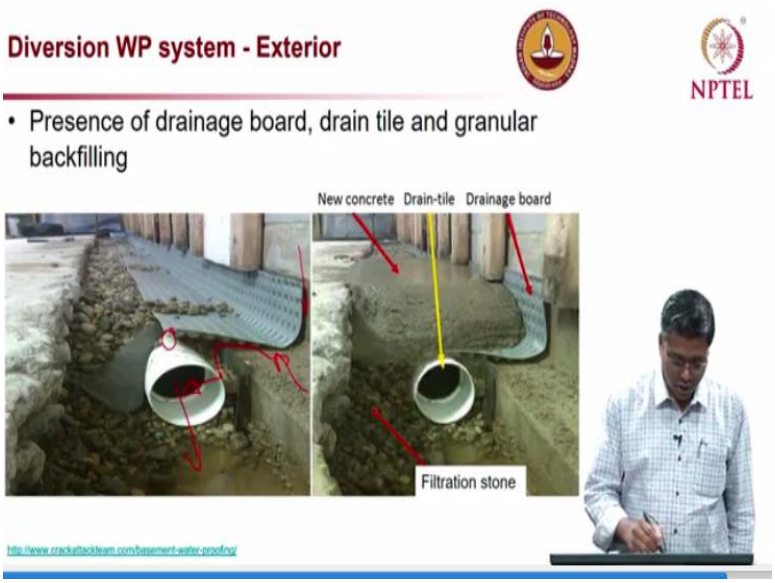

This another example photograph which is making it more clear, you can see here drain board, so whatever water coming from the ground it will collect it through and then get it into the pipes. So these pipes have little holes on that. So that water will get into the pipe and then flow outward, so this is the idea.

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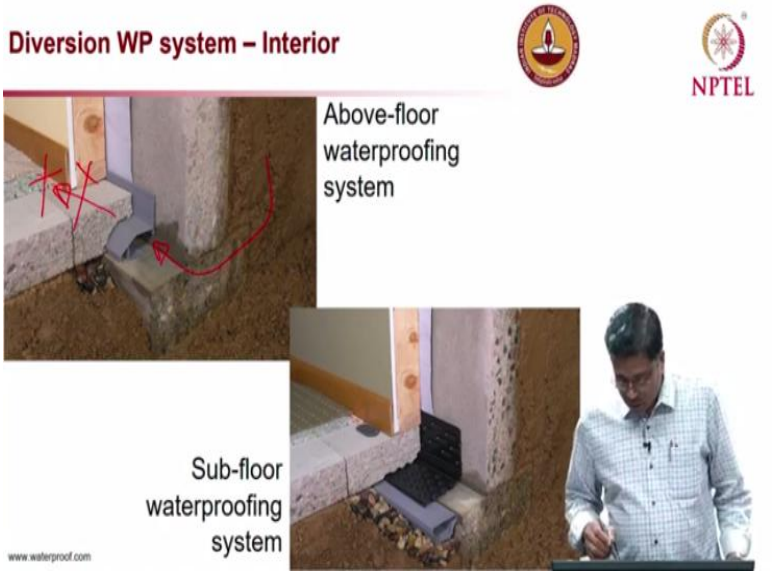

Similar thing, again here you can see different type of these systems, instead of drain board or different type of commercial products are available which all does similar thing basically, they all prevent the water from entering the building, this is not allowed.

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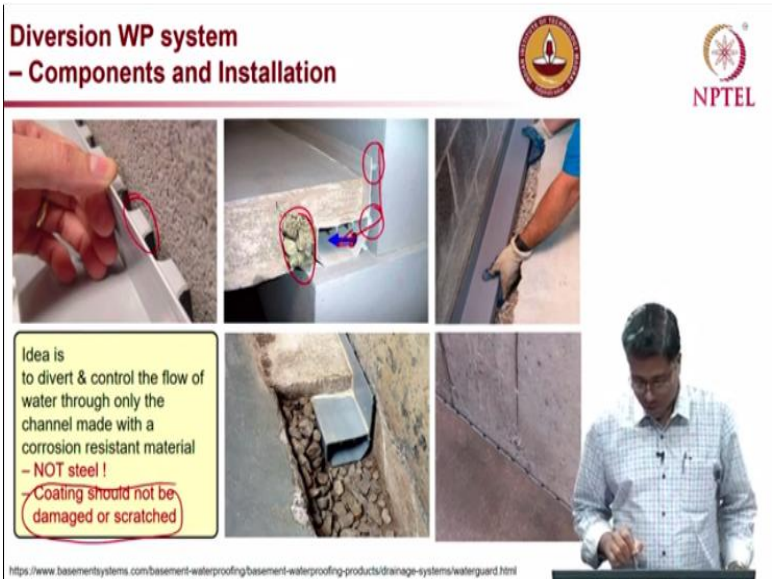

Now, again here it is not just laying a pipe over that, so there are some design features also associated with this, you can see here this spacing between the concrete and the particular element as you see here; there is spacing that is very important. So this spacing is very important because you want some air space over there for the water to accumulate and then take it into the pipe.

The blue arrow over there is showing that how the water is coming through and then getting into the French drain and also this gravel is very important because you want water from all around to be collected and then forced it into the drain pipe or which we call French drain and then one more important thing, the drain is not made out of steel usually, it is better not to use any corrosive materials.

We should use highly corrosion resistant material because you are dealing with water. Coatings are not usually used unless we can protect them from scratching or any damage, it is better not to go for coated metal system. So it is always best to ensure that they will be corrosion free otherwise, after few years down the line, you will end up in removing the entire system and replacing.

And then you might say that the system doesn't work but actually the problem is that the system itself is corroding and not really functioning. So, when we select something all these have to be written in the specification in the technical specification itself, we must do very good homework on what are the possible deterioration mechanisms and then select the

materials and systems to make sure that those deterioration mechanisms do not occur during the lifetime expected or the during the service life expected.

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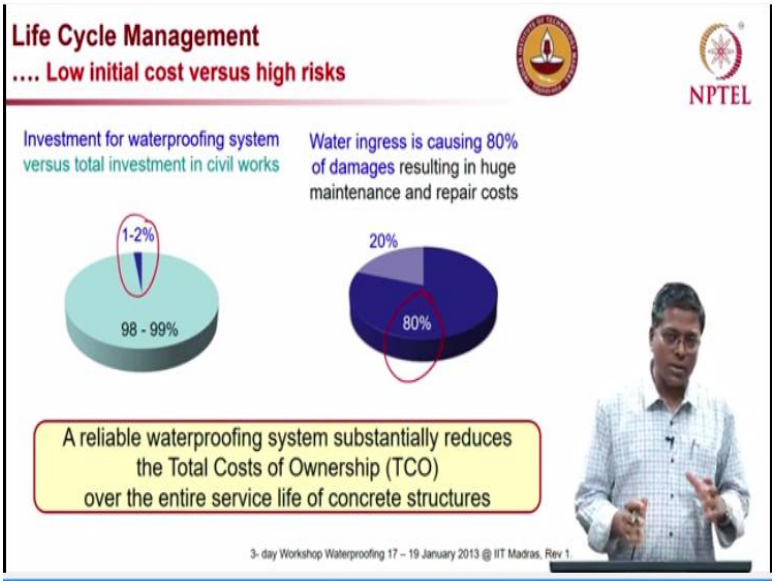

Before ending, let me also tell little bit about how important it is to consider waterproofing like, installing new or installing specially designed waterproofing systems, when we talk about construction. Usually, we don't do it because or I am not saying, we don't do it, we do but sometimes it is looked as something very expensive.

But that is not really true because, typically, if you look at a project cost as such, the waterproofing systems and materials used for waterproofing might cost you only about 1 to 2% of the total project cost but it can save you 80% of the money which you will otherwise spend in controlling or in managing the water or in preventing corrosion etc., etc., which will happen because of the poor waterproofing systems.

Not only corrosion in this case, we are also talking about delamination of the paints and lot of other problems. In fact, there are health issues also can happen because if there is mould which forms fungus. All those attacks can lead to other health issues for the inhabitants. So having said all that I think we should really think about waterproofing, when we talk about new structures.

And also repairs, think about waterproofing and then look at the cost of the waterproofing work as a function of the total cost of the project and then value it

appropriately rather than just looking at an absolute number and then deciding on not to go forth.

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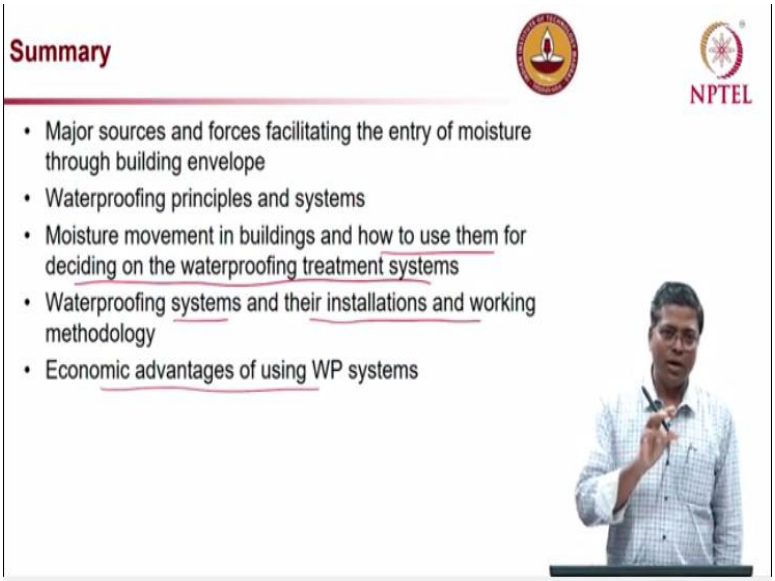

So to summarize, we looked at the major sources of water and what are the different forces like the principles of how water gets into the buildings and then we also looked at how water flows through the building and how to use them for deciding on water proofing treatment systems and then we also looked at waterproofing systems and some typical systems and how they can be installed.

We looked at the barrier waterproofing and then we looked at drainage and diversion type waterproofing systems towards the end, we also talked a little bit about economic advantages. So we can spend very little additional money in capital and that can save a lot of money in minimizing the moisture attack in the buildings, thank you.