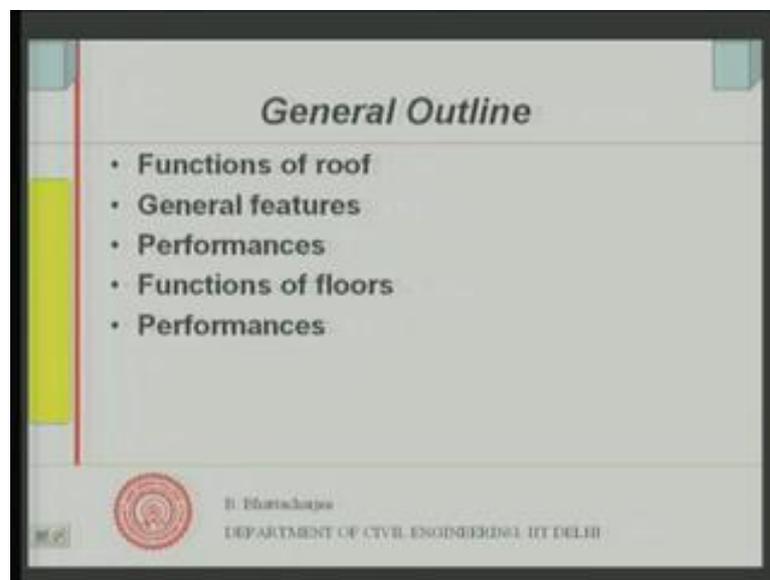


Building Materials and Construction
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Module - 14
Lecture - 1
Roof and Floor Construction

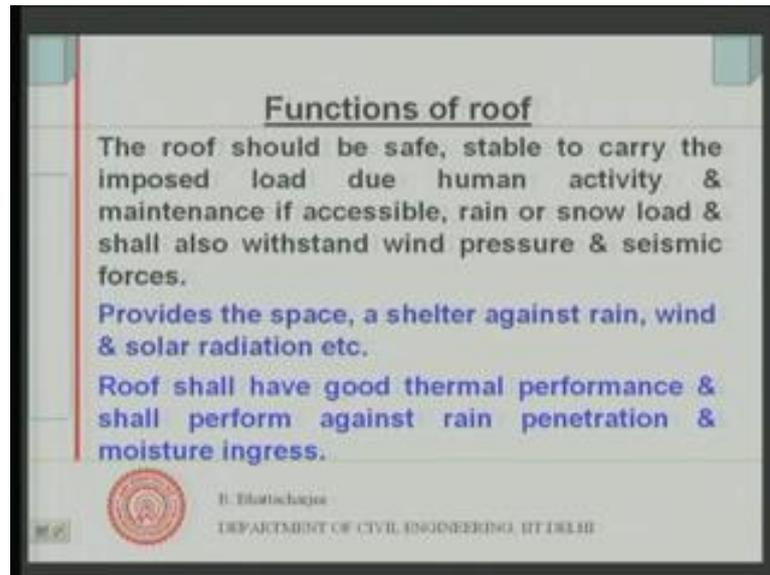
In the last module of this lecture series that is module 14 we have 1 lecture, and we shall be discussing about types of roofs and floors.

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So outline of our this lecture will be we talk about, functions of roof then we will discuss on general features of roof, performances of roof, and similarly we will look into floors and their performances.

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So, let us see what is a function of a roof; first of all you know the roof provides the top covering it is a top cover of the building top most cover of the building and therefore, it provides the outer cover to the space. And is essential component of the envelope it is an essential component of the envelope right. Therefore, roof should be safe, stable to carry the imposed load due to human activity.

So, you know and maintenance, not all necessary all roofs are accessible in fact if you look at the Indian standard code of practice for load; the load for inaccessible roof. For example, sloped roof in some cases they are not necessarily accessible for maintenance or putting water tank in etcetera, etcetera. So, the load is much less but where it is accessible it should be able to carry that load meant for human activity imposed load that will come.

So, then also should be able to carry the rain or snow load and shall also withstand wind pressure and seismic forces. Now wind pressure come, of course there could be a kind of a pressure on to the direction on the direction on wind ward side of a roof. If there is slope roof, pitched roof, slanted roof, garble roof whatever you call them sloped roof essentially.

So, on its leave ward side that is called that is direction, on the away side of the wind, you know wind direction like when wind comes and impinges upon 1 side and that we call as wind ward side. And the other side is the leave ward side if you remember, then

on the leeward side you can have partial vacuum. So, that kind of wind forces it should be able to withstand and also any seismic forces.

Now as I mentioned it provides the space, a shelter against rain, wind and solar radiation. And therefore, it is an essential it is also an essential component of the building envelope, the outer envelope it forms an essential component of the outer envelope of the building. And thus it should have good thermal performance in addition to structural stability.

So, it should be stable to withstand all the load that coming from the human activity the imposed load and should be able to also, withstand the wind pressure if there is any. And in the seismic forces that may eventually it will encounter, during the service it should be able to withstand all that snow load, rain load.

Because, rain fall intensity will you know accumulation of the rain load will actually depend upon the intensity of the rainfall and the drainage that you have snow load accumulation of snow and. So, it has to take care of all those, in addition it must since it is providing a shelter against rain and wind and solar radiation it should have good thermal performance.

Because, this is the roof which is itself a maximum solar radiation and therefore, it should have good thermal performance. Because, you know this is exposed top is always exposed to the sunlight. If it is a wall it would say not facing a wall in northern hemisphere in away from the equator, you know on northern latitudes it may not receive any sun light; during summer except early in the morning and late in the evening.

But if you look at the roof, it receives all the time radiation we are talking of tropical climate, not beyond tropical climate. So, in India as you know value the latitude varies from 8 degree to about 31 degree; 8 degree in Trivandrum and 31 degree being J&K somewhere, in Srinagar around 31, 32. So, latitude being with in this range between this ranges you are likely to have solar radiation may not have all walls, but definitely you have maximum radiation in the roof.

So, roof is the most important component from thermal performance point of view therefore, thermal performance of roof is important. And it should definitely shall perform well against rain penetration this is most important and moisture ingress,

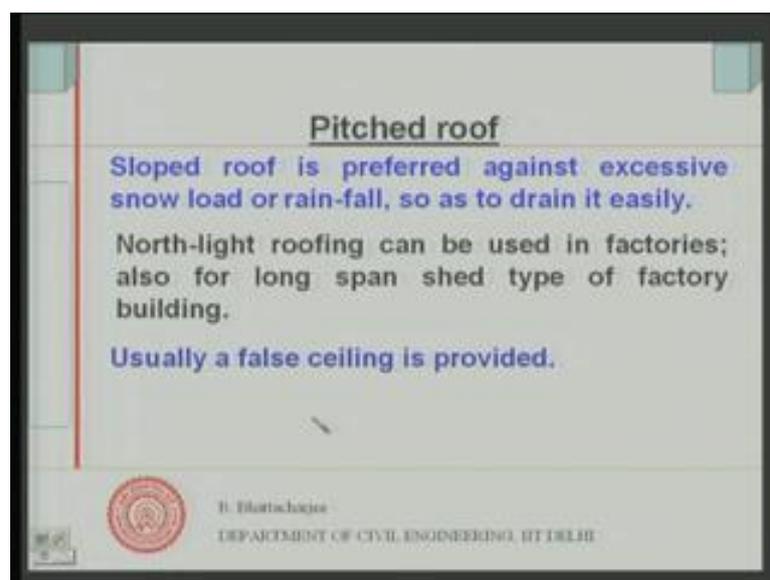
because rain penetration is very important here. Rain penetration one think it creates discomfort if you remember we talked about, some sort of something about dampness.

So, this rain penetration creates sort of a discomfort visually it is a discomfort, because rains comes you know moisture ingress condensation or moisture ingress takes place inside. And if the moisture is seen at the surface, at the ceiling or wall this of course, gives us a kind of discomfort that is number 1.

But there are other issues, the other issues are it actually can trigger off deterioration of the structure of the member itself, depending upon whatever is the structure member. Because, moisture is the main thing it is a main agent for deterioration of most of the materials and structural elements therefore, it has got 2 fold effect.

First of all it looks visually does not look nice, it will just destroy the internal finishing may be paints and such things. And besides that it will trigger of additional deterioration of structures may be in RCC structure it might cause reinforcement corrosion and its eventually the concrete will start falling. So, moisture ingress case very very important in case of roof and that is to be fully taken care off. So, performance against rain penetration is very important.

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Now, we can have pitched roof or you know what is called sloped roof now this is preferred against excessive snow load or rain fall. So there it can drain easily, usually in

hilly areas or cold areas this is preferred and usually in low raised building, not in very tall raised building and not very tall multi storey buildings.

Usually not, but you can have of course, you will have certain and disadvantages in such situation we shall look into that. But usually used in, you know place where there is excessive rainfall, snow load, etcetera, so as to drain it easily. And then factories in factories used in factories, you see north light roofing can be used in factories so north light roofing is of different kind it can be of the flat roof also it can provide some sort of roof lighting.

Because you know long big sheds, long sheds you need there lighting it is interior which you cannot get from. The wall the wall can provide you, wall you know like if you have a long shed something like this very long shed. So, shed is something like this, so this is very long, this is length is very long and distance from the wall to the interior points somewhere here is very large.

Now, in such situation day lighting even if you provide some windows here let us say you provide some windows here; day lighting will reach depending upon the height of the window, width of the window day lighting may not reach at the center part. So what you can do? You can provide some sort of roof lighting there, so that is lighting. And usually such lighting is provided in the north side why?

Because, we said for the lighting purposes we do not want directional light, that we discussed in connection in earlier in connection with in various connections. That we do not prefer direct sunlight you know in connection with glasses we are talking about. So, we do not prefer direct sunlight why? Because, direct sunlight will bring in direct solar radiation in and lot of heat also.

In addition to visible radiation it brings in lot of long wave heat radiation as well, so we do not prefer that. Besides that direct sunlight when it is coming, it can be a source of glare1 issue is seeing it properly, so you need a minimum level of light in terms of brightness or in terms of illumination lux whatever we call it.

But in addition to that 1 important issue is, if you have too much of light and contrast and similar situation you can have glare; you know you are familiar perhaps if you look to

the light directly. Let us say, a car light directly car head light directly; temporarily your vision is actually disturbed.

Because, you just cannot see it disable it glare here; so we just do not see it because too much of light has fall on to your eye retina and it is all scattered in all direction, so we do not see. There is something called discomfort glare, which is also associated with the too much of brightness contrast and such things you know, contrast difference between object and surrounding.

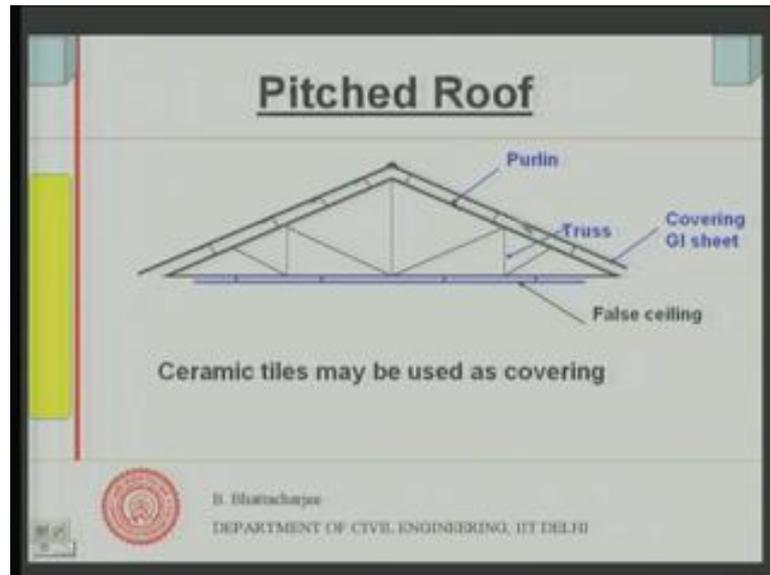
So, brightness difference between object and surrounding so; when we have direct sunlight chances of glares are more. So, we do not like direct sunlight, because it brings in heat and it results in glare. But we want actually what is known as diffused sunlight that means, it can it is diffused through particulate system in the atmosphere or reflected from ground or reflected from other building.

So, we prefer that kind of light which is not direct, not peculiar, but you know it is a diffused sunlight that is better for vision, that is better for visibility and that you can get from north direction that is why north light roofing. Well in northern hemisphere it will come from north direction of course, in southern hemisphere it will come from southern direction. So, in Australia or Latin America it will be different, but in India we have north light roofing and that can be used in factories.

Now, when you use that kind of factory shed then we use basically pitched roof quite often we used pitched roof; pitched roof or sloping roof. In buildings of course, you might need a false ceiling, because the space that is actually that is and there is some amount of unutilized space between the bottom of the roof system and it stop the some triangular unutilized space usually.

But that can serve as a purpose of insulation also and quite often I would like to provide a kind of false ceiling, not in factories, but if it is in a single storey building and such buildings which are used let us say, in hilly area son north eastern part of the country earlier. Now off course now many thing, many places flat roofs have replaced this, but wherever you were using we might use false ceiling.

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So, this is what it would look like a typically you know just a typical diagram. First the structural system and this structural system usually is a truss; you know earlier it used to be timber trusses. But you can have steel trusses tubular section of steel trusses and varieties of trusses that could be there. And you might have seen this is in railway platforms they are of course, the truss system supports the railway platform the shed type.

So they are of course, slightly different they do not look the top, does not look triangular; but looks in some form something you know the similar in nature basically you have the pitched or sloped roof there. So, structural system is made up of truss which there are varieties of trusses which we are not discussing here; we might discuss it would be discuss somewhere else in structural analysis class then this are the purlins.

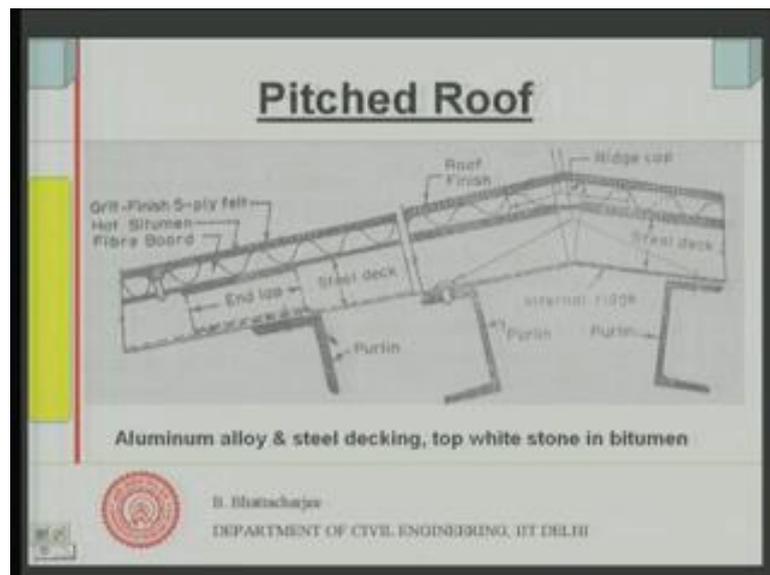
So, you know this 1 which supports the roofing system this is called main rafter of course, you are dealing with the structural design of them and analysis then you would be knowing. But at the moment for our structural point of view this is the purlin, and then this is the top covering some time it could be Gi sheets, it could be tiles or some many other things.

So, that is how a pitched roof looks like and this is of course, the false ceiling may be suspended from the truss system here. And this would be this would provide you know

this space is blank; in factory you can leave it blank that is no problem. Many other places you may not like to keep it blank from aesthetic point of view.

So, if you provide a false ceiling this within the room thus, so this can then provide as a kind of sort of a vacuum, you know or rather sort of an air filled space which will act as an insulation.

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So this is how the pitched roof normally typical pitched roof will look like the cover this could be ceramic tiles and many other sort of things can be ceramic tiles can be used for covering. So let us, look at it we have 1 more of this pitched roof Aluminum type for example, this is what I was saying is a purlin; this is close to the ridge and this is away from the ridge.

So, this is having also some insulation at the top Aluminum and Aluminum alloy and steel decking a special kind of sloping roofs system, pitched roof system and this top is actually hot bitumen as it is known and with grit. Grit means, we have white stones on bitumen with finish with 5 ply felt. And this kind of thing can reflect, if it is a white stone it can reflect a lot of solar radiation, because we do not want it we want better thermal performance.

So, heat should not come in this system also since there are some space vacant space inside this can act as an insulation this is a steel decking right, this is a steel decking; the

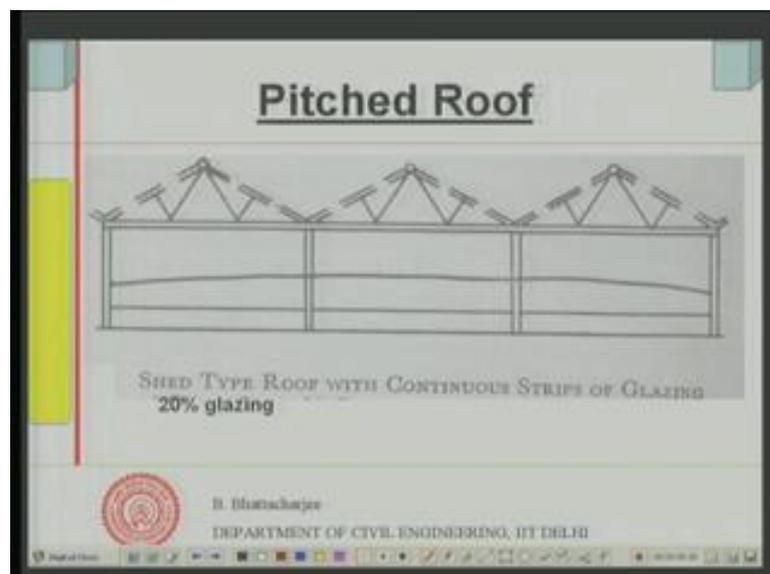
purlins are here; this is the steel decking. And this as you can see the roof finishes at the top, which has got the felt and fiber board here inside which will act as insulation and this is of course, the ridge cap.

So, this can this sort of a system can act good well we have good thermal performance as well. In addition to cover large span, so when you want to cover large span very long span like in factory and sheds this is still used, because truss system is very useful structurally to cover large span. Flat roofs would be normally very long you know very very, very wide or very large column free space for flat roof is difficult.

So, either you have to have shell roof you can have varieties of kind of shell or folded plates. There are other kind of structural system which can support the large column free spaces in factories, auditoriums and similar sort of structures. And there the roofing would obviously, if it is concrete system then the roofing could be similar as what we discussed for the flat roof system.

But in many cases you have large column free spaces are covered by trusses; simply from structural reason not necessarily for rainfalls factory sheds quite often you will there. But where you need lot of insulation or lot of better thermal performance one can go in for this sort of thing with white finish at the top, white stones grit finish at the top and then you have fiber boards and so on insulation allowing you to have good thermal performance.

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This is a case of north light you know or light roofing this is not north light, but this is overall with 20 continuous strips of glazing. So, this spaces that is there, this spaces that is there, this spaces here, this spaces here. You have actually glazing means, glasses to bring in light this will of course, if you have on both sides it will bring in direct sunlight as well.

But, if they are translucent then it will allow only diffused light to come in. So, we can have translucent surface not really glass surfaces which will bring in direct solar radiations. But, translucent surface diffuses it do not will not allow transmit peculiar radiation pass through it rather it will diffuse the whole thing, so you can have translucent.

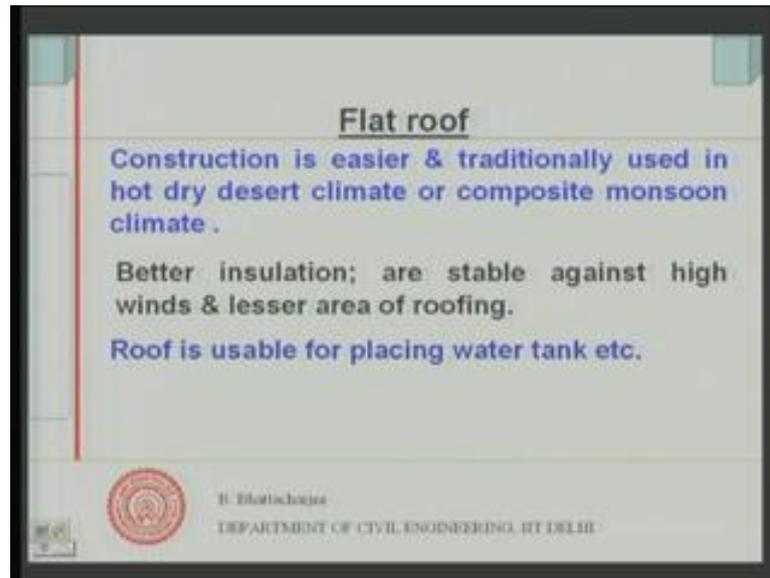
Many other cases simply on 1 side you have an opening of this sort you know just extend this and you have an opening here. So, this is glass this portion is not there light can come in if this was the north direction. So, roofing system can integrate the lighting their lighting purpose also normally their lighting in normal building of course, it is through the wall, windows, the glass right.

So, as far as glass is concerned, as far as their lighting is concerned it absorbs only 15 percent 85 percent it will allow it to come in. And diffused solar radiation I mean light it allows to come in it will also have some amount of you know transmittance is less than 100 here as well. And maintenance is important, if you maintain the glass clean then of course, the lighting will be better, but if it is see there is something called maintenance factor.

So, it is expected that maintenance factor means dust accumulation on the glass or the translucent surface bringing in light should not be there. The maintenance factor should preferably be never below 0.7, so that atleast 70 percent of whatever light is incident visible light is incident; comes inside there you know there light comes inside. So anyway, roofing can be combined to get sufficient their light.

So, this pitched roofs are used for that purposes as you can see, the truss and the factory building along factory shed and continuous strips of glazing here. You know translucent glazing here on all this spaces, but you can have other kind of systems also.

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So, this is how pitched roof is used well both structurally as well as structurally as well as for functional purposes. Now, pitched roof definitely has certain disadvantages, because it is not easy to have human activity up there. So, you cannot place a tank water tank if you like; you cannot have any kind of the terrace is practically unusable for human activity.

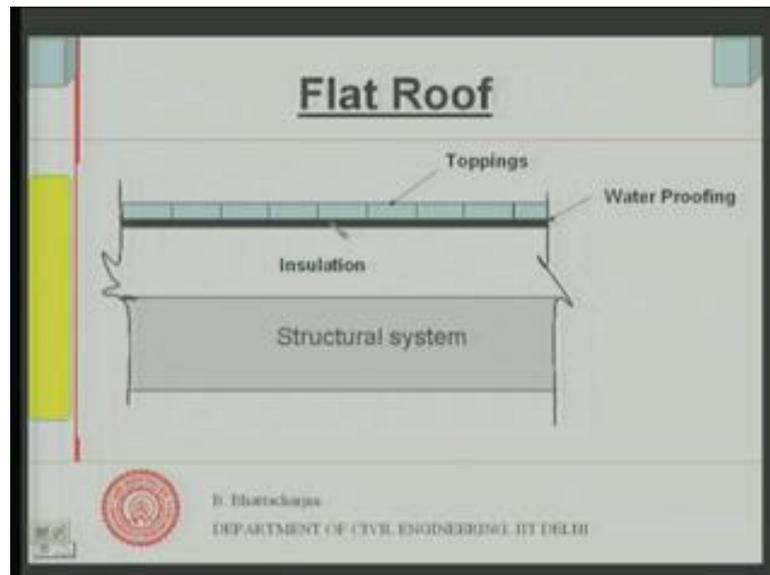
But, advantage is where there is high rainfall you can drain it of very easily; even the space area required is large in case of pitched roof. Because, total area material we need would be more. Your covering area and the roof area is more compared to the area that you are covering, so flat roof has the same area. So, flat roofs have got certain advantages construction is easier traditionally used of course, traditionally they are being used in hot dry desert and composite monsoon climate.

Because, they are in hot dry desert climate in many places like, Rajasthan in India they have stones available and earlier they were using stone. In composite monsoon climate of the central India many places this sort of roofs have been traditionally used for very very long time. Otherwise also modern day of course, flat roof is almost used everywhere particular in multistory building.

Because, you would like to have water tank and similar other things sat the top for water supply. So, you'll make use of the same and concrete has been a useful material and since it is a little bit economic you would like to use this also. You can get better

insulation in this particular case and has to be of course, stable against high winds and is you know it is more stable against high wind. Because, it is only partial vacuum that would be created on top of it as the wind flows horizontally. So therefore, its stable most stable high wind and of course, lesser floor areas is there right as I said it is usable.

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So, flat roofs are used in many places and typical flat roof would be generically it would look like this. You will have a structural system here as shown and some insulation, because thermal to improve the thermal performance. Then, definitely you will have a kind of water proofing and the top finish. That is very important the top finish that is the general structure of any kind of flat roof, there are varieties of such flat roof used in different parts of the country.

But in any case the modern days, whole idea is functional performance what do you want. So, structural system is wanted like truss in the inclined roof they are supposed to carry the load or support you know support itself provide the shelter, safe shelter total covering. So, it must be supportable to support itself or any load coming due to wind etcetera rainfall, snow or other things.

So, also any load coming, because if it accessible human load would be there. So, that load it should be able to carry and the structural system is here. This could be reinforced concrete in earlier ones reinforced bricks so were also used, but now it is mostly

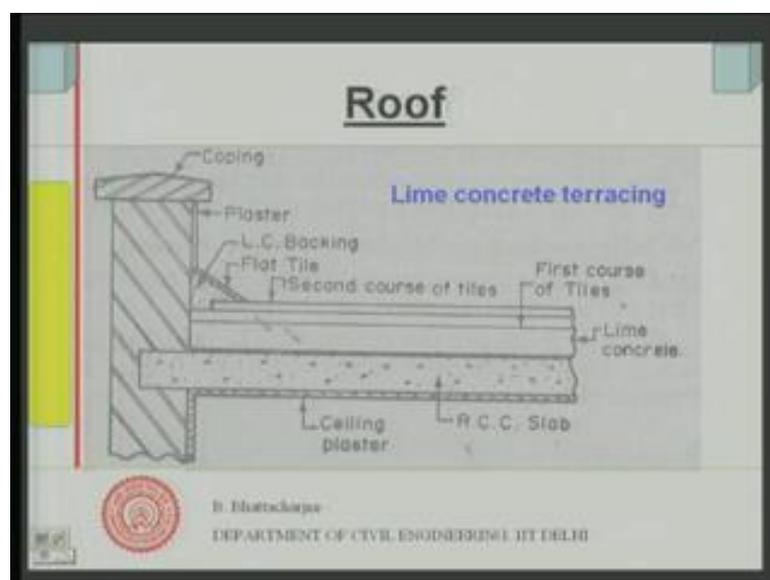
reinforced concrete. Then you have insulations; the insulation could be of the varieties of kind.

For example, you can have today varieties of plastics and polymer coming in as insulations, foam systems on several other system of insulation is possible, rather than using simple traditional mud fuska and similar sort of lime terracing. I mean as we shall see in some other kind of insulations mostly straw mud combination or many others.

So, you can have varieties of insulation possible here today modern days and then of course, you must have a water proofing system. And then finally, finishing topping which could be tiles or some other kind of finishing. Because, if there is a human activity here then there will be abrasions and it should be able to withstand that.

Traditionally ceramic tiles I mean a brick, clay brick, sort of clay tiles have been used which are thinner than the normal bricks and that has been used; you know something like 15 millimeter thick tiles have been used in northern part of the country. So, this is a typical construction of a flat roof.

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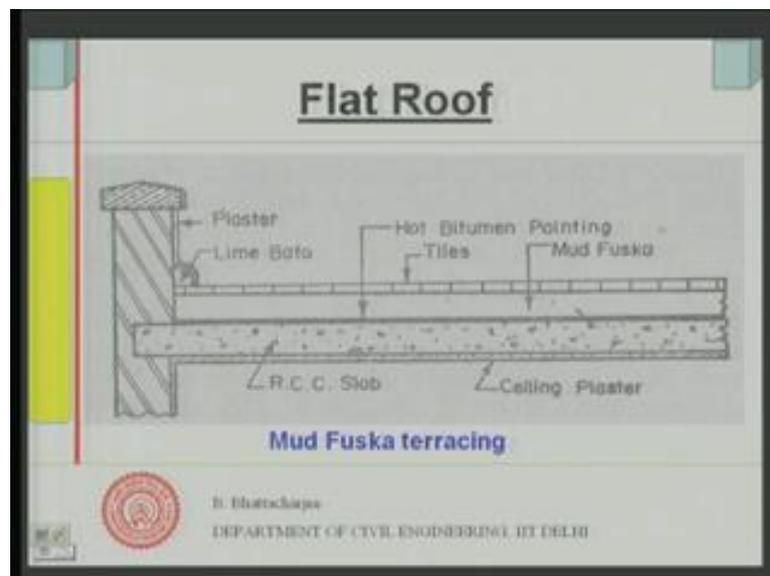
Now, this is what is commonly known as a lime concrete terracing I just picked up 1 or 2 of those types. There are several others traditionally that has been used but as I said, today it is not necessarily that you use the traditional ones insulation could be quite different today. And obviously, RCC is the structural system the slab is. In this case it is

supported on wall, it could be supported on any other system like columns and beam, beams and then columns for infringe construction.

Then, you have got ceiling plaster; ceiling plaster this will protect this also provide better fire resistance depending upon the situation. And then you have got lime concrete and then first course of tiles, second course of tile and this is lime concrete backing flat tile this is supposed to provide you know this is essential to provide actually moisture stop moisture flow in to the mortar or by passing this into you know the wall systems or similar sort of thing.

So, this is what is known as lime concrete terracing as you can see, this is a lean concrete and should support do somewhat as insulation also provide a thermal mass. Now, thermal mass is very important if it is in hot desert climate and therefore, will provide a sufficient amount of thermal mass we will talk about this a little bit later on. So, generally being used in desert sort of climate.

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And this 1 has been used for very often in composite monsoon climate now, this is Mud Fushka terracing again this is RCC slab, ceiling plaster and this is the Mud Fushka which act as an insulating material. Well since we know the functions today, we need not use very traditional material I mean you can use them. But we need not use them, if we have some other material or easily available not so costly materials as available which have got better life.

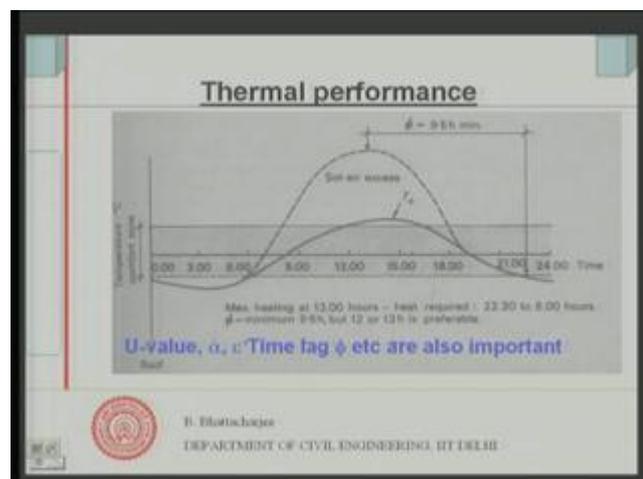
So, you know supposing that durability is better their functionally they are better than we can use them also. But, traditionally this has been used very much in composite monsoon climate and this is an insulation material. This prepared in straw with Mud; Clay Mud you know clay and this is this gives us a fiber reinforce sort of a fiber and straw is actually void.

So, it will have lot of voids inside and these voids provide thermal insulation you know as we have talked about earlier, in connection with the wall u value etcetera that closed void system they provide good thermal insulation. But it is not necessary that you use this material, it must be in insulation this is traditional I have just shown is this.

On top of that you will have tiles, and then you have a between them of course, you have got since this Mud this depending upon the insulation type if it insulation is water absorbing, then then you have got to have the water proofing here.

Because, this is Mud and it can absorb a lot of water, so you want to have of course, you want to save the concrete so put the water proofing here. So, what bitumen water proofing here and then the top tiles which will protect this Mud Fusha and you know for human activity and so on. So, any abrasion etcetera will be taken care of this and this 1 is the insulation. And at the corner it is very important, that you provide sufficient kind of protection against rain penetration and that is what is done this coping of the parapet and that is what is the flat roof system.

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Now if you look at thermal performance this is very important, Thermal performance you can see the 2 things: first of all outside temperature is an important issue as we discussed earlier. But roof receives maximum solar radiation, so this is a temperature profile TO is temperature profile outside and this case is for a desert area hot dry desert.

If it was not a desert, then this value could have been you know this is somewhat higher, this is somewhat lower, this is somewhat higher, this is somewhat lower, variation would have been much less the diurnal variations are less in warm humid climate, which is the in most of the coastal area north east of the country that is called warm humid climate.

So, where diurnal variation is less day today variation maximum temperature during the day and the minimum temperature their difference this is called diurnal variation this is relatively less in such situations, where as in case of desert climate which you see in the north western part of the country Rajasthan. And similar areas the desert area, the diurnal variation is very large particularly in summer.

So, you can have very low temperature early in the morning and very high temperature during the peak day time. So, this difference is very large and as you can see this pic actually temperature is attained somewhere around local time about 3 pm or so.

Now, in addition to that the roof will receive maximum solar radiation, so this curve shows is the equivalent temperature due to solar radiation. So, I mentioned to you sometimes that radiation is received and this radiation can be converted into an equivalent temperature. So, effective temperature if you may call it the what we call as a sole air temperature this will look like this.

Sole air temperature which thus take the solar radiation and also the temperature into account, so this is this sole air temperature. This portion we call as sol air excess, above the solar you know the normal temperature and this total we will call as sol air temperature, which is an equivalent temperature taking account of the solar radiation falling on to the surface.

Now, this temperature peak would be realized somewhere here and you can see this temperature profile you know if this is my comfort zone of temperature within a room.

So, it may it may go below the comfort zone at certain point of time, in this case about you know 9 11 or 10 to 11 pm in the night.

So, what you can do is you can provide sufficient time lag; you remember I mentioned about time lag earlier in connection with wall there is a phase lag. Peak here would actually cause peak heat flow into the room 12 hours later how does it happen? If the roof can absorb a lot of heat before radiating it back within the room right and the there is a time delay, such that it absorbs do not radiate it immediately radiates it somewhat later right.

So, there is a time lag in time delay and this in technical terms we call it as phase lag, because it is a wave form actually temperature waveform so there is a phase lag. So, if this phase lag is about a 9 5 hours then then it would reach at 11 pm the peak heat flow inside the room will be at may be 11 pm.

So, when the temperature has gone below the comfort level that means, you will start heating the room for the comfort. So, you can well utilize if there is sufficient thermal mass. So, no wonder lime terracing which we showed earlier is used in Jodhpur you know it is or used in such areas where you need large thermal mass. Since you need large thermal mass, you know that which can hold on to the heat and transmit it much later traditionally they have been used that way.

So, you will have thick walls everywhere in those areas thick walls, so that it absorbs the heat and then radiates this much later. Even in composite monsoon climate in hot dried desserts season or similar season May, June or similar season you have hot dry this could be useful. But anyway point is, you can utilize the thermal performance of the roof to a beneficial way in dessert climate.

In other cases also, thermal performance in tropical climate should be such that it should be able to reject the heat as much as possible; should not allow the heat to come in. So, in conditioned building u value will be very important you remember the u value we talked about in connection with the wall. So you can find similarly, the u value of the roof, so u value is important. Absorb absorptivity solar radiation absorptivity alpha to solar radiation is important.

So, we will not like this value to be high, we will like this value to be low. So, that it does not absorb much of the heat that comes in. So top surfaces keeping the top surface white, colored with white stone as in case of Aluminum of course, you cannot use them. So, you cannot white wash the roof if it is usable. If it is a useful roof where people go you cannot white wash not a flat roof, because if you white wash it will get washed away in no time and it will not be effective actually.

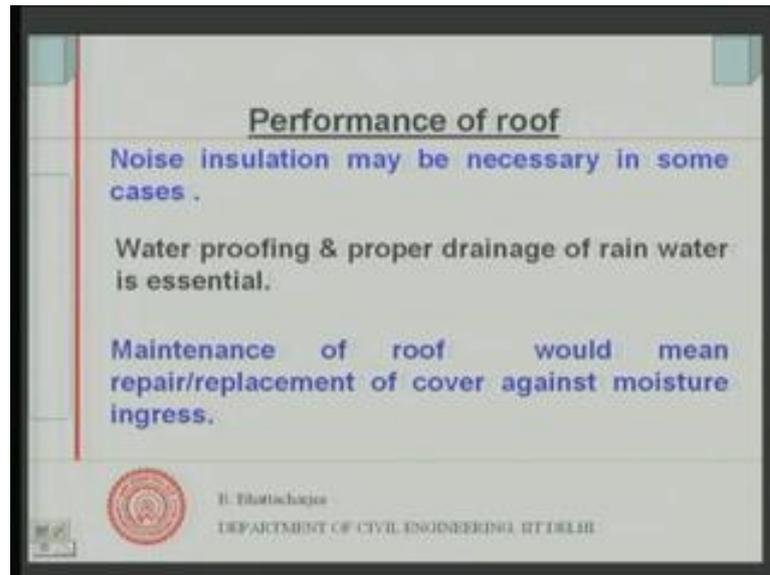
But if it is white with kind of grit or you know white stone or such grits you have placed and made it white, it would possibly be not absorbing as much. But if you make it texture there are other features, other passive way of doing that, but if you put it too much texture it may not be usable. So, 1 has to be judicious about such things, such that alpha of the roof should be less solar absorptivity, solar radiation to solar radiation should be less.

Epsilon is the emissivity of long wave radiation, which should be high. So, in the night it should radiate as quickly as possible and in white surfaces many of the white wash or similar surfaces have this kind of property. So it should have high long wave of emissivity surface, top of the roof surface then time lag 5 I mentioned you know this is important and also how much decrement, how much reduction in heat takes place.

So, that is to periodic heat flow these are important thermal performance; in 1 humid climate of course, you may not need very much the mass it can be light weight, because you do not need the mass why keep it. Because, it will add to structural loading so; you do not need much, but insulation is a good property even there.

Because, it will receive maximum radiation there the diurnal variations are relatively less, but the humidity is usually very high. So, in such situation air flow becomes very important the roof system also should be such that it allows for lot of air movement. So, anyway this is what the thermal performance of the roof system.

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So, if you look at the performance of roof, noise insulation may be necessary in some cases we have seen thermal performances is needed we need of course, structural performance as we have seen. Noise insulation may be necessary in some cases for example, where it is close to lets us say let us say an auditorium. Then, you might need noise protection, because if it is close to airport and you have an auditorium.

And this noise from the top should not the aircraft noise, where susceptible to such things the noise insulation may be also important. But most important is, water proofing and proper drainage of rain water this is the most important issue this is most essential. Because, rain water penetration as I said it can cause secondary effects rather than primary effects it can cause even secondary effects like causing deterioration of the structural system, so this is essential.

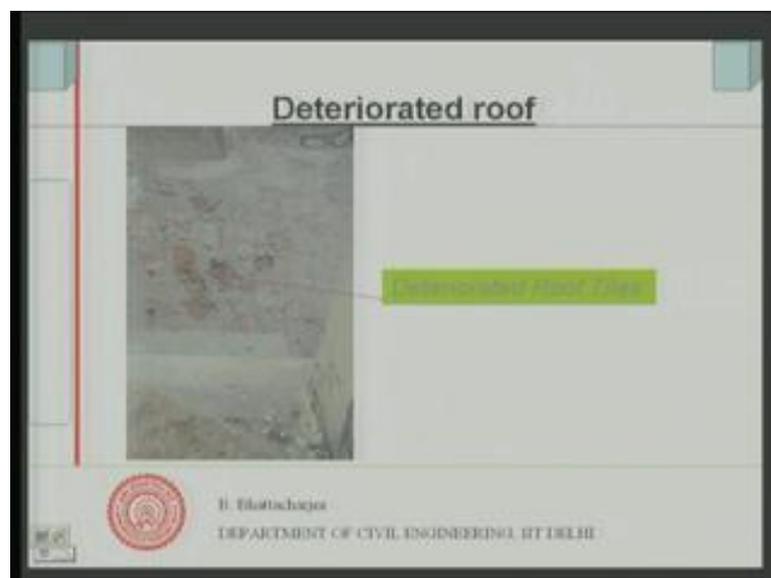
Maintenance of roof is required to see that it does not allow moisture penetration, so this is very important. So, let us look at how what happens you know moisture in fact right 1 normally, I have to replace the roof cover, because it allows moisture ingress say about 20 25 years normally the life is 20 25 years.

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Some of those examples we have are something like this a deteriorated roof, so we can see this deteriorated roof. Now this cover top cover has gone here and leakages will take place through this 1 has to maintain this deteriorated roof covering top cover. And this can leave you moisture ingress I mean long run, it can results in actually deterioration of the concrete system as well.

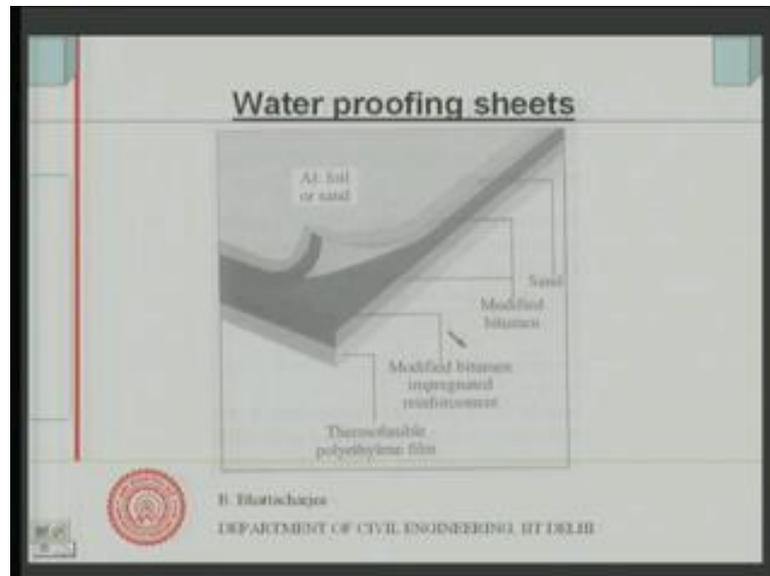
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So, this is important this particular roof is after about 25 to 30 years deteriorated roof tiles as you can see top roof tiles which are actually brick, clay brick roof tiles. And this has started deteriorating and therefore, there are several cracks and water penetrates

through it and causes durability problem to the concrete reinforce concrete element below, so this is an important issue.

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Let us see, how do you do damp proofing? A common way of doing using membranes or you know water proofing of this kind. So, in this system you have a bottom this is the water proofing sheets modern days this is very commonly used. But you can use varieties of kind of system in fact, you can have a polymer modified concrete system.

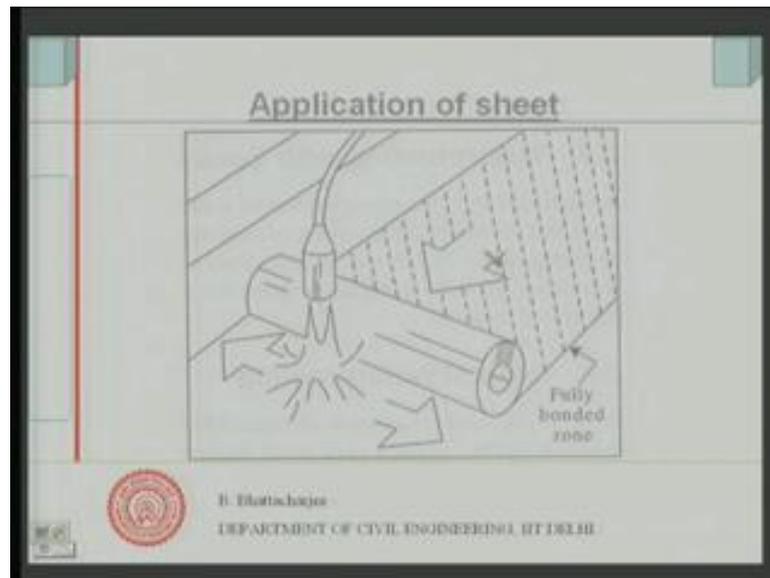
So, this is of course, membrane polymer modified concrete system laid over the concrete already existing water proofing very dense polymer modified concrete system and it would work in the same manner. But this is most common this is the modern ones are looks like this; you have a bottom polyethylene film which will melt under heat.

So, that you can apply over the surface, then on top of that you have got modified bitumen system. Modified bitumen reinforced with fibers earlier of course, people were using natural fibers like jute, Hessians etcetera. But today you can have synthetic fibers which do not deteriorate easily. In fact, jute would or Hessians would actually hold on to the water and there can be glistening, but this is natural fiber I mean synthetic fibers I can use.

So, synthetic fibers you know reinforcement this can be made into a bitumen by bitumen integration bitumen impregnation you can make into a system of reinforced bitumen

system. So, this this modified bitumen impregnated reinforcement system you can have and this on top of this this 1 is the layer. And top of this we will have Aluminum foil or sand, that would Aluminum foil reflect; light solar radiation very well or sand even it will texture the surface if its white sand it will have good solar reflectivity also.

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So, this is the material that 1 uses and how it is applied? It is applied like this. The application is something like this, you have this material and heat up torch it up you know this 1, so as you roll it up the fully bonded zone. Because, you have heated it up and as I said it is thermo fusible, so it melts and then sits on to the surface.

So, this is for the roof system membrane system that is commonly applied and it is very important to ensure the corner are done thoroughly the circular; corner of the shape of the corner we said this should be done keeping no gap anywhere without complete system should be actually protected.

There are other polymer systems for damp proofing as well like, I mentioned the polymer modified concrete system and several other system, but this is most popular.

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Let us look at the floors; the floors should be safe, again the functions of floor if you look at it floors should be safe, stable to carry the imposed load depending upon the function of the building and shall also withstand wind pressure and seismic forces. The load that the floor has to carry will depend upon what function you are supposed to carry. If it is a factory building then the machine loading will come, if it is a classroom the loading will be accordingly.

If it is a residential building, loading will be accordingly and IS: 800 which gives you the load it is according to the function of the building. So, floor loading would be based on this, so it should be able to withstand that load and remain stable and also wind and seismic forces if it is providing any kind of load that should be it should be able to withstand. This provides a platform for human activity within the space.

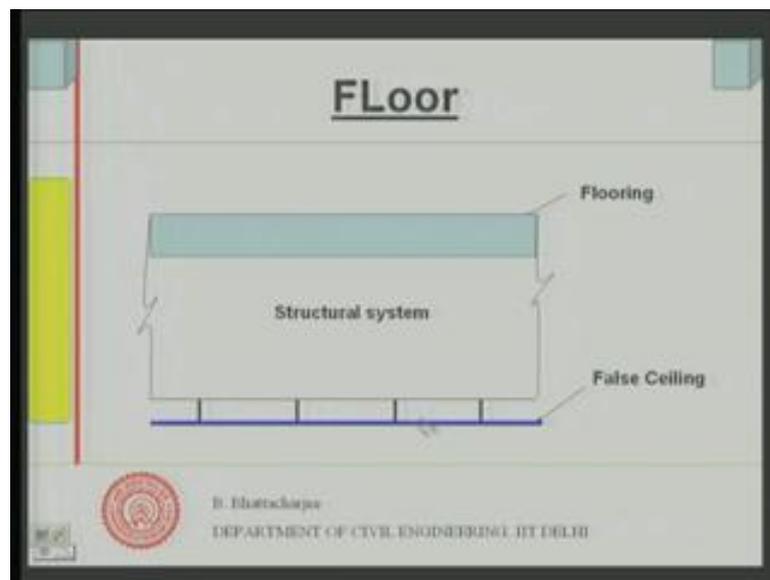
So, this could be a different level as you know like ground level of course, you do not have much problems, structural problems, but you can you can think in terms of dampness of course, they are that is the main problem could be. But at other levels of course, this floors have to withstand the load and accordingly the structures system provides. It this provides also the platform for human activity within the space.

For example, if it is a factory then mechanical machine loading abrasion from the machine would come, so I has to think about those. So, it should but definitely it should have good fire resistance, load should have good fire resistance and we discussed about

the fire resistance sometimes earlier. And should have good abrasion resistance and chemical resistance some time, because if it is a chemical factory of chemical might spill on the top layer might give away.

So, it should have good chemical resistance some cases noise quality, noise control, noise insulation qualities are also required and this is in specific cases would be necessary so one has to look into those.

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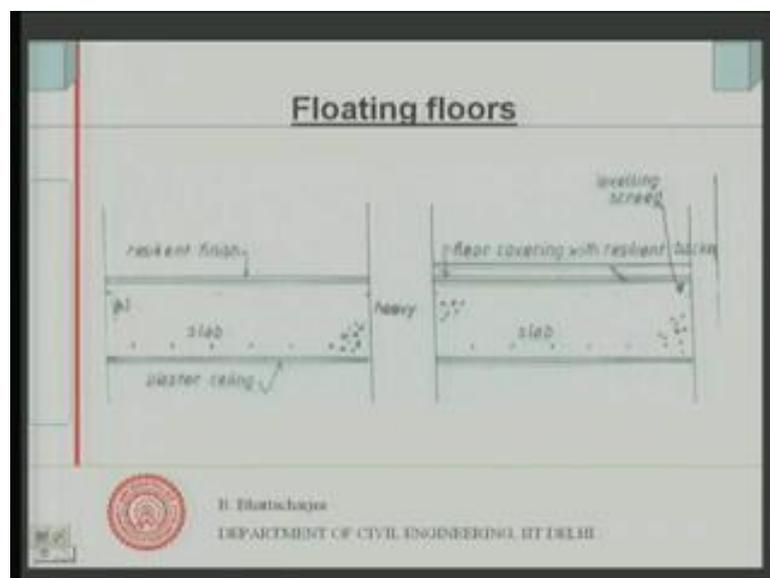
So, this is the basically broadly the functions of floors and typically it will look like this you have a structural system that is a reinforced concrete or whatever it is usually RCC these days. Then, you have a flooring system you do not have much of as I think to do see in thermal performance is may not be a very important issue here; because it is only separating between 2 spaces.

So, if 1 space is very warm compared to the other if they are maintained at the similar temperature you possibly would not need much of a thermal performance of the floor system. But obviously, you will need certain other things structure, so if you will look structural system the finishing is very much there this looks the variety of system finishing could be of varieties of kind. And you might require a false ceiling in many places, you know suspended from the roof system itself.

So, this may even house the duct in a ducts for transmission of services say air floor ducts or even electrical ducts and so on in certain places. And obviously, fire protection of those also is very important; you have fire dampers and similar sort of thing, but then that we will not discuss at the moment.

So, some cases you may have false ceiling could be having of gypsum and we provide better fire protection also as you know. There are various kind of false ceilings are possible boards could be there and they would be since they are they depend upon what is the function what is the usage of them. So, that is how a typical floor would look like.

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Now, let me look at noise protection most important in case of floor are the noise protection. Now, noise should not be transmitted from 1 room to the other through the floor now, then how the noise can be transmitted there are 2 mechanisms through which noise get transmitted: 1 is called air borne noise, other is the structure borne noise.

For example, if you have foot fall if you have stamp the floor then vibration is generated onto the structure, and then transmitted in to the next room right. Because, the vibration of the structure itself or transmission you know of the movement of the particle about their mean position of equilibrium in the structure. So, that is a structure borne noise.

But supposing, but anyway the stamping will also generate some air borne noise, because it will cause vibration in the air. And that can be transmitted through the structure

directly or even through flanking various openings are there, so it can bypass the floor and can go in the different manner, but that is anyway we are not looking into. But there are 2 types of noise as we understand structure borne noise and air borne noise.

And in case of wall we have seen that air borne noise can be transmission of air borne noise can be controlled or what we call noise insulation was transmission loss. So, 1 side you have generate a noise air borne noise it should not be transmit to the other side. And it is a function of the mass per unit area, so you have emissivity then air borne noise insulation quality improves.

Mass per unit area is high, noise insulation against air borne noise increases that is what we have seen. So of course, noise insulation can be improved by multiple layers that is what also we have discussed earlier in context of air. That if have more than 1 wall layer right double leaf wall or noise insulation becomes better of course, point is that there should not be acoustically connected. The 2 leafs of the wall should not be connected acoustically.

Now, in floor they will become important in many places for example, in case of library let us say or in case of a dancing floors orgames in multistory level let us say, in some floor we have such activity. There can be possibility let us, say even in a kitchen dropping of steel in metallic utensils. This will transmit the noise to the next level, so that is a structure borne noise.

Air borne noise and structure borne noise both noise can be transmitted through the floor. Now, how structural borne transmission of structure borne noise is controlled by providing resilient damping material at the surface. So, wherever noise is generated you have a resilient actually material which will absorb this noise and will not transmit this.

Floating floor constructions mainly meant for this sort of situations where your both structural borne noise as well as, air borne noise and you do not want them to be transmitted through the floor. So, these are called floating floors special construction.

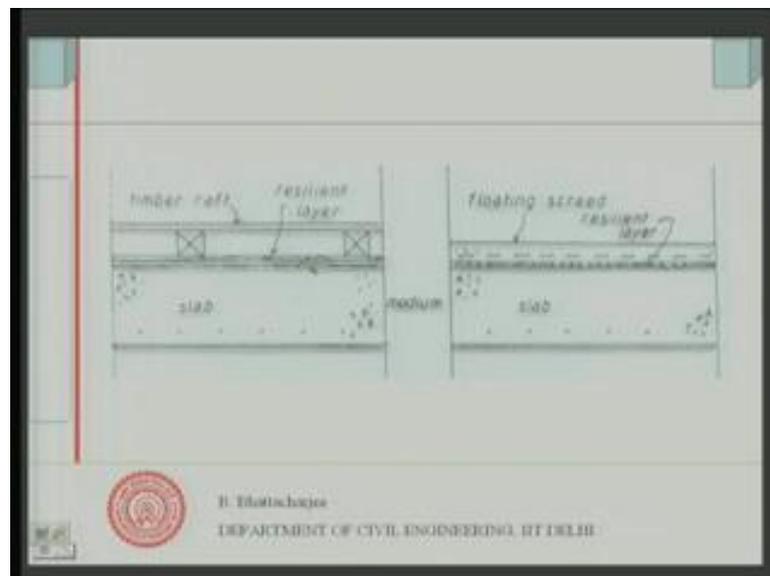
Now, simply you can put a carpet on top of the floor and that will provide you good resilient surface for transmission of you know its transmission again structure borne noise. Because, if you have carpet you can drop utensil or do a foot fall or stamping on to

the stamping on to the carpet and it does not get transmitted, as you can see you do not hear that noise.

So, they provide resilient finish can provide good structure borne resistance against structure borne noise. But if you want also air borne noise insulation then you provide mass. So, floating floors combine both effects depending upon the situation for example, this is a heavy floating floor, so you have a heavy slab and then you have a resilient finishes is 1 case. In this case of course, resilient finish means something like screed or coorg floor finish or rubber floor finish, linoleum floor finish.

So let us see, that such sort of tiles could be there which will not allow structure borne noise to be transmitted. You can have emissivity massive slab, so this slab is massive so air borne noise will not be transmitted. If you want still further air borne noise to be reduced, you have a resilient backing is here and you know levels screed here; resilient finish and then you have a floor covering here. So, this is cushion these are resilient cushion here available over the floor top, so this is 1 situation.

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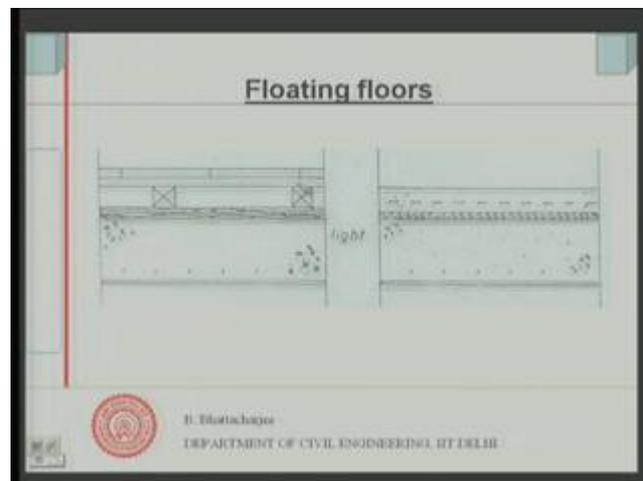


So, you can have medium slabs the mass of the slab is medium, but what you have done? You have actually providing this is a baton timber; timber is also a resilient material as we have discussed earlier; you have actually resilient layer here sort of a screed or you know coorg or timber even and then this is timber connected is timber.

Then, you have the timber raft on top of it, so it is a timber floor finish and you can see there is an air gap. So, it is almost acting like a double leaf, so air borne noise will be also little high and since this resilient cushion is provided here; structure borne noise will be insulation will also be high. Both air borne and structure borne noise will be high, the slab is of course, here medium you need not heavy slab.

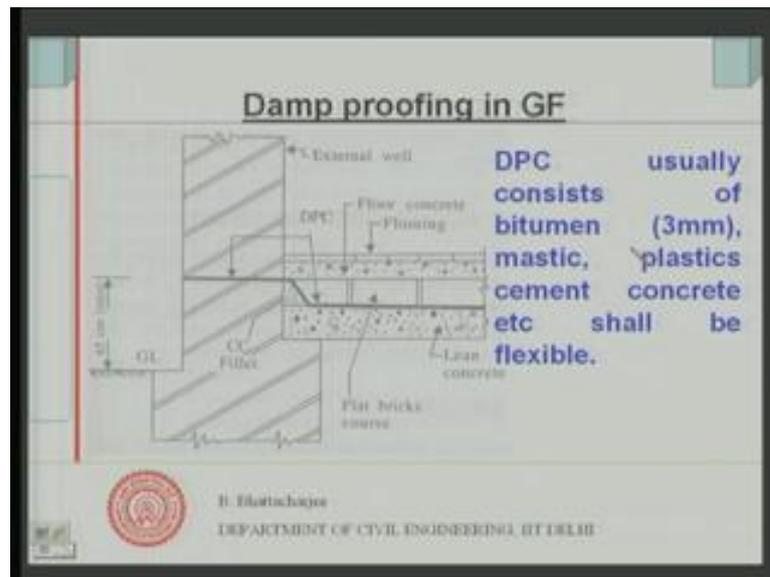
Because, you have provided a kind of air gap which will increase the resistance against air borne noise. Similarly, you can see floating screed resilient layer on top of it floating screed finish and the slab and this will give you a floating floor against medium slab.

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If this slab is light mean, weight might me went for some other issues. You can have floating construction like this for example, this is the resilient finish. So, we have that the timber and have a resilient cushion timber and have a resilient cushion you know finish on top of this.

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So, this is how you can have floating floor construction for noise insulation for various floors. It is used in dancing floors libraries multi storey library buildings let us say, so every floor will have this kind of you can have this kind of construction where you do not want any noise structure borne noise to be transmitted.

Or you have some kitchen or something below that you have got some place space, which we do not want to destroy in such situation you can use floating floor construction.

Then let us, look at ground floor they are damp proofing, we have discussed something about this earlier if you see and DPC we have discussed about them sometime earlier. So, this is the DPC damp proof course, I mentioned earlier you have plain lean concrete and of which you have if you see them floor concrete for ground floor moisture control.

So, here you have you know lean concrete is the bottom base of the floor in case of ground floor, moisture control is very important. You provide this DPC and we will talk about DPC material in a short while time and this is the floor concrete and the flooring finish right DPC is here and this is flat brick course just a brick course.

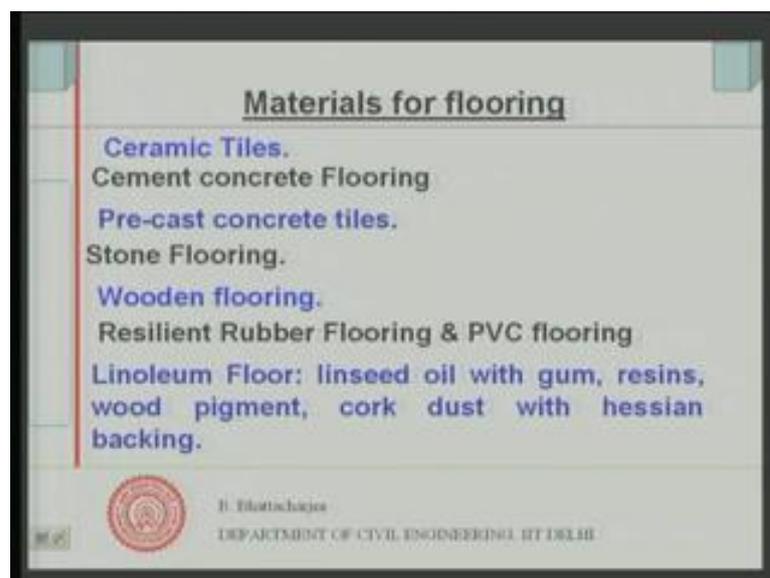
On top of that, you will have floor concrete right this is all lean concrete and then you have the fine floor finish. And this DPC of course, continues through and through you know this is the ground level and just at the plink level, as we said we provide the DPC

in the wall. So, the moisture no moisture can penetrate from this ground to the floor and this is important of course, ground floor we do not need any structural support or such things.

So, typical ground floor will look something like this. DPC usually consist of what material bitumen material 3 millimeter thick mastic or various kind of plastic system today you can have various kind of plastic system or you can have cement concrete with water proofing admixtures, which I mentioned in the context of concrete.

So, you can have water proofing admixtures together with concrete or you can even today as I mentioned you can have polymer modified concrete or such concretes which can, which is very dense do not allow moisture to impregnate you know it is not impervious to moisture they would be useful. But most commonly used is of course, the bitumen type.

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Let us see, what are the materials for flooring; ceramic tiles they are been used in many places as you would see ceramic tiles in many places various kinds of vitrified tiles could be there. Terrace or tiling construction could be there various kind, then cement concrete flooring this is very very common in most of the places cement floor concrete flooring is used. And it must have good abrasion resistance, if you were used in used infactory or similar sort of thing mechanical industry.

So, how is the abrasion of concrete is measured, basically measured by various kind of test where you grind the concrete in a standard manner and find out the percentage of the powder or similar there are varieties of other test as well. So, concrete you know cement concrete flooring can be used for good abrasion resistance. Pre cast concrete tiles they can be used for similar sort of things, stone flooring in some other places, wooden flooring is used in floating floor construction just some of them I have shown.

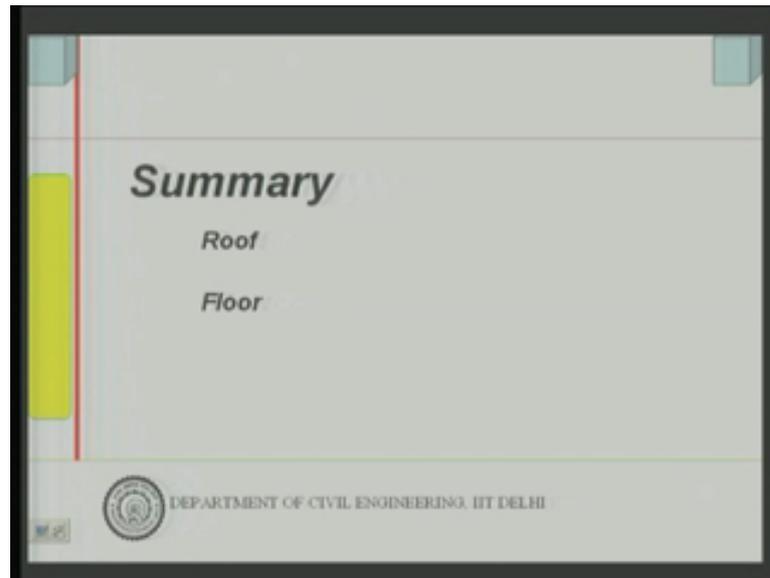
Because, supposing you have a floor for indoor games now this would require, because 2 issues are involved the noise you know it should have good damping characteristic. So, that it absorbs most of the impact as well as the vibration or noise that would be generated. So that, the noise is not too much of noise is not generated within the room itself.

And of course, if it is in a floor it should be transmitted to the other room. So, wooden floors are this purpose, because it can absorb most of this it has got good resilience and damping properties. So, it can absorb most of the noise and do not allow it to be transmitted to the next floor level also if you have floating construction below it.

So, wooden flooring is used in such case so; if you have indoor game table tennis or badminton then the flooring of this ones are good. Resilient rubber flooring and PVC flooring is very much rubber tiles or PVC tiles they are used in many places. And linoleum flooring which is costly is actually linseed oil with gum resins and wood filament or pigments and cork dust.

So you have basically linseed oil with gum, that is the main thing and the resins of course, for bonding then you have various kind of filler like wood pigment, wood or cork dust which actually has good resilient good resilient property. Pigment could be used for color purposes and with a usually with a Hessian backing. So, this are the materials for flooring used a floorings use and we have seen mostly seen the material types of flooring that we use. In of course, in as shown short time that we have and we have also looked into types of roofs in this lecture.

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And with this actually we conclude this module 14 module of roof and floor construction and we also conclude this particular lecture series. So, as the summary of the lecture series itself we can look into it look into 2 issues mainly: 1 is the material that we use and the construction. Some of the construction processes we have looked into as far as concrete is concerned, we looked concrete as a material.

And we have also in the beginning try to look into the functional purpose of buildings what are the issues related to building construction namely, what are kind of what is the functional performance we expect from building. That is what we looked in the beginning, then we looked into certain construction processes and the materials; processes are related to the material for example, we looked into concrete production process and then we looked into concrete as a material.

We looked into machinery as a material and the walls and the function of the walls. We have also, looked into other material which have come into being now like, polymers related things like pastes adhesives. We have looked into metal steel mainly, as reinforcement also as structural member, structural material.

Then, we have looked into timber little bit and glasses, which are the other construction. So, as much you know this are the basic materials, but by far definitely we have not gone it to too much of details of this materials, because the time possible it is not possible to cover everything.

Details can be looked in detail course as one each of this individual material and construction that we have looked into. So, lastly we have looked into roof and aspects of roof and floor construction and I think with that we conclude this series of lectures.

Thank you