Strategies for Sustainable Design
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Lecture 31
Climate Responsiveness

Hello everyone, in this lecture we will discuss about climate responsiveness. So, in the previous lecture we studied, we discussed the vernacular architecture. So, the strongest feature of vernacular architecture is the relationship with the climate. So, the how this strategy of climate responsiveness has worked wonder for the architectural system. So, it forms across different places. So, we will see those things and we will try deciphering some more climatic responsiveness strategies which are very important for design.

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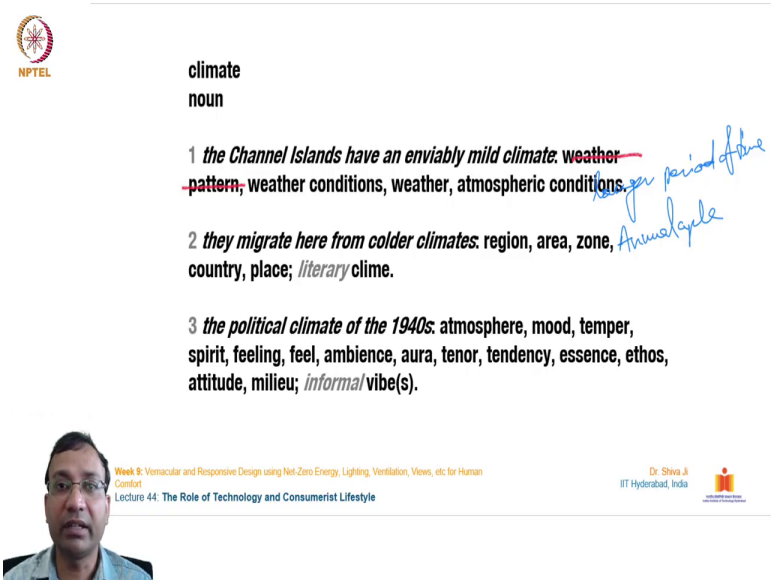

So, if you see the simple definition of climate. So, what is the weather climate? So, climate is the longer period of may be prevailing the environmental conditions which are imposed by the nature on any given place. So, it has to do with the weather pattern. In that weather pattern which last for a longer period of time. And that longer usually we take it in a cycle of one year. So, that thing that naturally occurrence of this prevailing atmospheric environmental conditions collectively we know them as weather climate.

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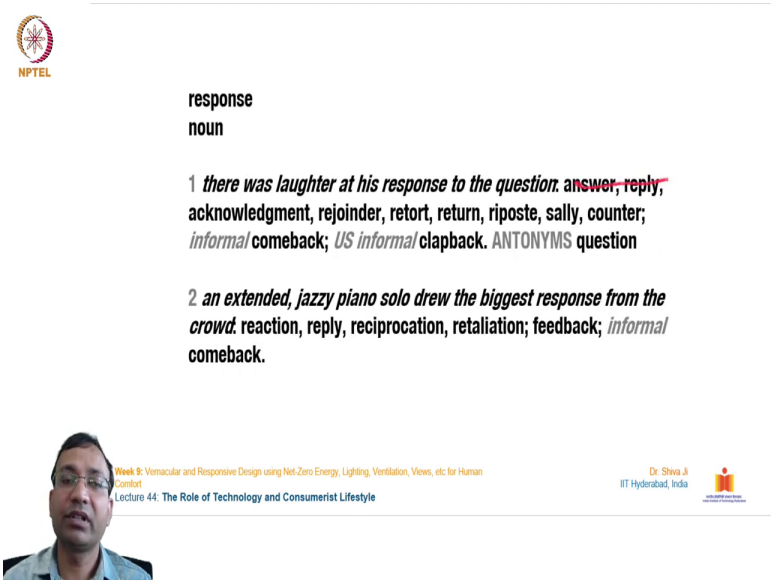

And what is responsiveness? So, responsiveness is a very simple is the answer to that given situation.

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So, when we see, so, this is the climate and these are it is elements of this climate. So, the climate is a long-term record and trend of the different averages of these elements of climate. And weather which happens on the day-to-day basis. So, whether for example if it is a rainy day or a cloudy day, so that is as a resultant of weather.

But if the several months are going to be sunny or rainy or very cold or chili or snowy, so that because of the climate, so the climate runs in the planet on annual basis and weather we have hang on the daily basis. So, you can see the elements of climate so that is the sun, the winds, the humidity, the temperature, the precipitation. So, collectively these are the elements and in a combination of these elements a climate is constituted.

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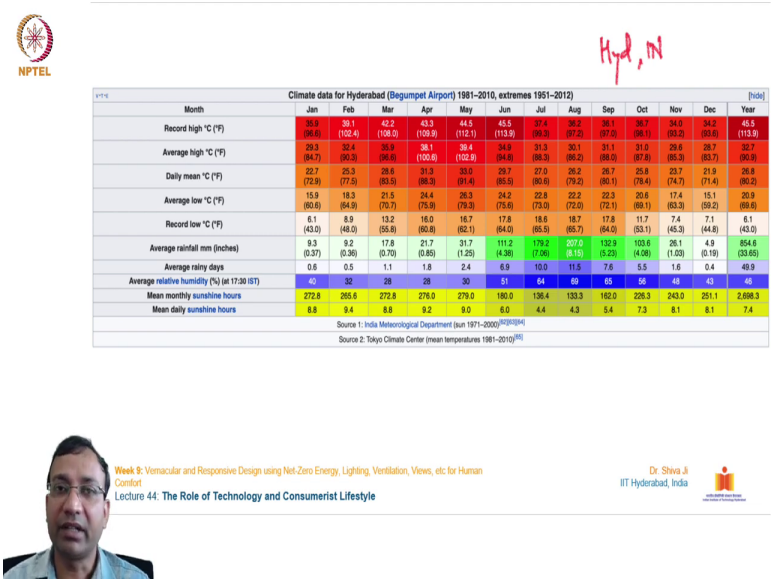

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C (°F)	35.9 (96.6)	39.1 (102.4)	42.2 (108.0)	43.3 (109.9)	44.5 (112.1)	45.5 (113.9)	37.4 (99.3)	36.2 (97.2)	38.1 (97.0)	36.7 (98.1)	34.0 (93.2)	34.2 (93.6)	45.5 (113.9)
Average high °C (°F)	29.3 (84.7)	32.4 (90.3)	35.9 (96.6)	38.1 (100.6)	39.4 (102.9)	34.9 (94.8)	31.3 (88.3)	30.1 (86.2)	31.1 (88.0)	31.0 (87.8)	29.6 (85.3)	28.7 (83.7)	32.7 (90.9)
Daily mean °C (°F)	22.7 (72.9)	25.3 (77.5)	28.6 (83.5)	31.3 (88.3)	33.0 (91.4)	29.7 (85.5)	27.0 (80.6)	26.2 (79.2)	26.7 (80.1)	25.8 (78.4)	23.7 (74.7)	21.9 (71.4)	26.8 (80.2)
Average low °C (°F)	15.9 (60.6)	18.3 (64.9)	21.5 (70.7)	24.4 (75.9)	26.3 (79.3)	24.2 (75.6)	22.8 (73.0)	22.2 (72.0)	22.3 (72.1)	20.6 (69.1)	17.4 (63.3)	15.1 (59.2)	20.9 (69.6)
Record low °C (°F)	6.1 (43.0)	8.9 (48.0)	13.2 (55.8)	16.0 (60.8)	16.7 (62.1)	17.8 (64.0)	18.6 (65.5)	18.7 (65.7)	17.8 (64.0)	11.7 (53.1)	7.4 (45.3)	7.1 (44.8)	6.1 (43.0)
Average rainfall mm (inches)	9.3 (0.37)	9.2 (0.36)	17.8 (0.70)	21.7 (0.85)	31.7 (1.25)	111.2 (4.38)	179.2 (7.06)	207.0 (8.15)	132.9 (5.23)	103.6 (4.08)	26.1 (1.03)	4.9 (0.19)	854.6 (33.65)
Average rainy days	0.6	0.5	1.1	1.8	2.4	6.9	10.0	11.5	7.6	5.5	1.6	0.4	49.9
Average relative humidity (%) (at 17:30 IST)	40	32	28	28	30	51	64	69	65	56	48	43	46
Mean monthly sunshine hours	272.8	265.6	272.8	276.0	279.0	180.0	136.4	133.3	162.0	226.3	243.0	251.1	2,698.3
Mean daily sunshine hours	8.8	9.4	8.8	9.2	9.0	6.0	4.4	4.3	5.4	7.3	8.1	8.1	7.4

Source 1: India Meteorological Department (sun 1971–2000)[82][83][84]
Source 2: Tokyo Climate Center (mean temperatures 1961–2010)[85]

So, a typical if you see a climate chart for any city this is the example I have taken from the city of Hyderabad in India. So, in this chart you can see the average daily mean temperature in centigrade. You can see the average high in the different month. So, the record high which is happened in this plain. So, this data is from year of 1981 till 2010 and the average low in centigrade and record low.

So, this is about the temperature and the next the average rain falls in millimeters. So, how much of rainfall this place has received in these many years. So, those an average given and the number of rainy days per year how many days are rainy. And then average relative humidity rh. So, that is average taken of these all of these 12 months and then there is mean monthly sunshine hours and then mean daily sunshine hours.

So, with this you can understand it is very evident from here most of these months from this place Hyderabad they are in the warmer areas. They are either red, dark red, or oranges, and then yellows very few days are close to whites or close to like cream. So, that means this place has

majority of it warmer side and the hotter side only with the extreme temperature as you can see over of the years which has been recorded over is a 45.9 degree centigrade.

And in the months you see June is considered to be one of the hottest ones with the average record high of 45.5. And then the daily mean in of 29.7 degree centigrade. The lowest temperature which was recorded over here is 6.1 and that has I think recorded in the month of January. So, this is the distribution of this temperature in these many months and if you see the rainfall well August is supposed to be one of the wettest months with the 207 millimeters of rainfall in this month.

And other months for example like a January, December, February, March so these are relatively drier months. So, very minimal precipitation and average rainy days. So, here in the month of august 11.5 days are rainy days. And relative humidity also, has increased in those months of monsoon and with the 69 percentage. So, this is the overall, so this chart you can source for any city wherever you are living.

And you can just have a look at it this chart to understand the what kind of climate you are living in. So, this will give you some ideas like the how much is the average temperature, how much is the average humidity, how much is the volume, how much is the volume of rain this place is going to receive. Because these are the major constituent of climate. So, you can easily understand what kind of climate you are living in.

And how much up what extent it is affecting your comfort level and your wellbeing at that place. So, accordingly you can engineer all your designs, all your responses with these responses which you will frame for your designed for this particular place they will be known as the climatic responses. And these are very important for like design considerations.

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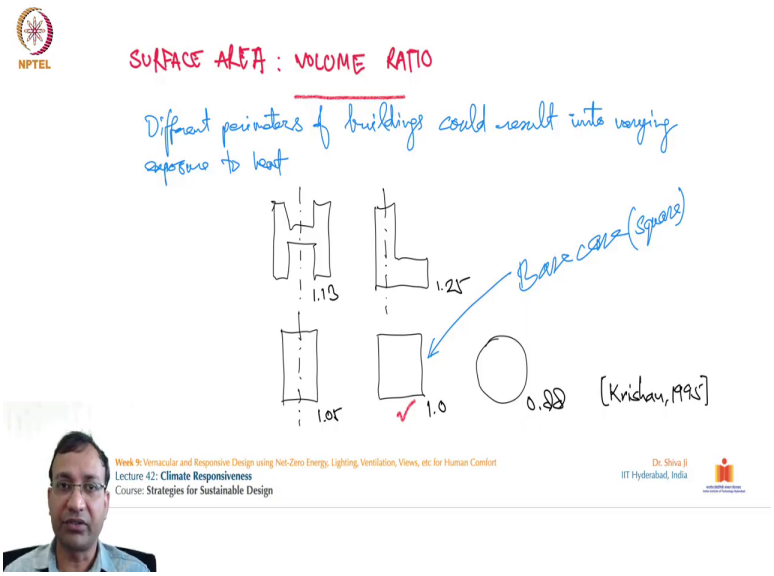

So, let us move ahead. So, when we talk about surface area compare to the volume. So, if we take surface of square in the massing chapter we have seen if we take a cube with 1-unit volume and 1-unit surface area. So, if we start disintegrating into while increasing the surface area of that volume or may be reducing the surface area in the given volume. So, how much of the energy requirements will increase by increasing the surface area.

Since the surface area will increase the exposure to the sun will also increase in the same proportion. So, if the sun exposure, the sun gain is will increase, the heat load on the building will increase. So, if you want that heat load for example if you are living in a climatic cold place then it is ideal for you to increase the surface area. But if you are not living in the colder place, we are rather living in very hotter places, then it is always desirable and recommended to go for minimizing the surface area, so that reducing the heat gain in the building.

So, in turn you will be spending a little or in a control manner for cooling that place. So, with the area given over here if square is base case which has 1 unit surface area or 1 unit of volume, then a circle would be even having smaller surface area up to 0.88. And this will be the most efficient geometrical, geometry to have to minimize the sun exposure. And similarly, you can see in the other rectangle L and H forms, so the component of this exposed surface area is increasing. So, increasing over in overall change the heat exchange of these geometries.

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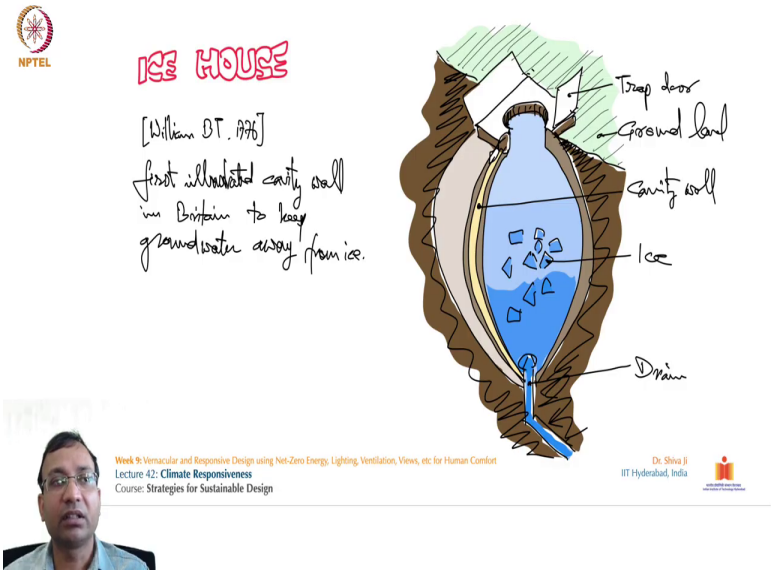

So, how this is used in a several places in the several countries in what ways so, we will discuss with the help of some case examples. So, in this structure if you see the this is the first illustrated cavity brick wall which was found in the country of Britain. And it the cavity wall is kept to keep the ground water away from the ice. So, this is the approach which has been used in this design over here. So, you can see how this is passing from the external side of it.

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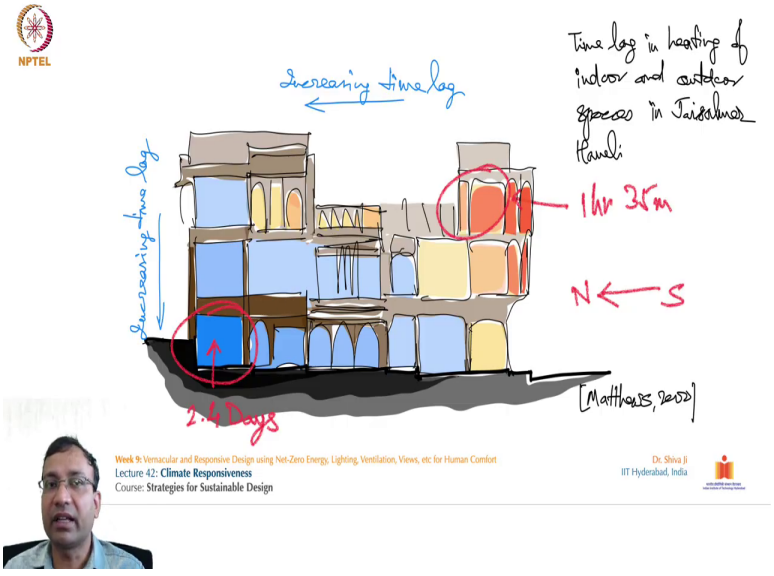

Further to this I think this is a very known graphic or illustration for us we may have seen it already n number of times. So, if you see how the Havelis in Jaisalmer India have been designed.

So, this is taken from Mathews 200. So, this side is north and this side is south. So, how the sun load from the south starts heating the building. So, the first exposed quarter of this building falls here on the stop right corner.

So, it gets heated in 1 hour 35 minutes time. And this heating of this bulk this entire structure starts happening from this side and it keeps pushing, pushing on the lateral this side and that is along towards ground floor. And it takes the different quarters used has been analyzed and given over here how much of a time, in the time factor is needed to heated these areas. So, this shows the time lag from here, from this quarter to the next quarter it is required to have spent 25 hours 5 minutes.

So, this actually portion will heat up from the outdoor lighting condition. And similarly on this side it will take 2 hour 49 minutes and, on the bottom, most left side if you see it will take 2.4 days to heat up this area. So, obviously if you see this entire cross section has several advantage using terms of its length and breadth.

How this build should be of this x length and y height in order to create some habitable quarters which utilized in the one of the hottest months of India in this particular place. Because Jaisalmer falls in one of the hottest areas, hottest regions of the world. And the temperature sometimes in the summer reaches to the extreme.

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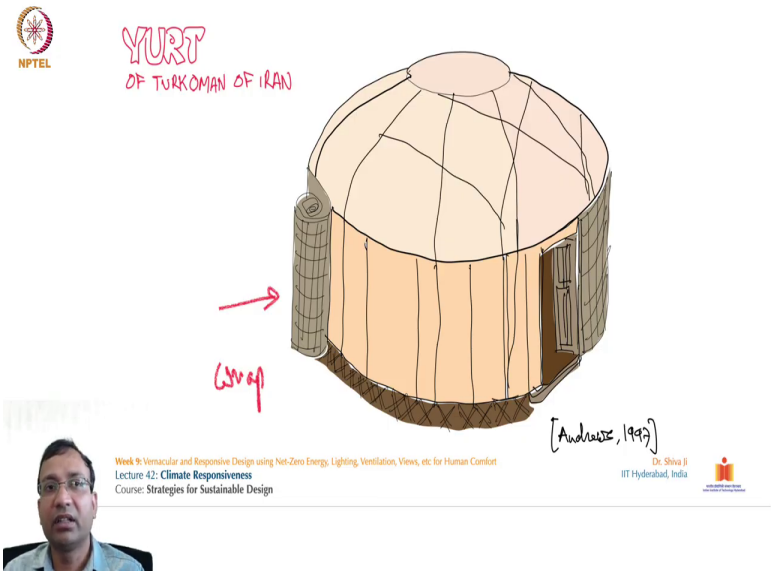

Further if you see how this tribe in Iran has evolved his methodologies of using a different material in different cross section in the different fashion. You see this is rollable mat of these grass and other material which works as a insulator element for covering this building structure.

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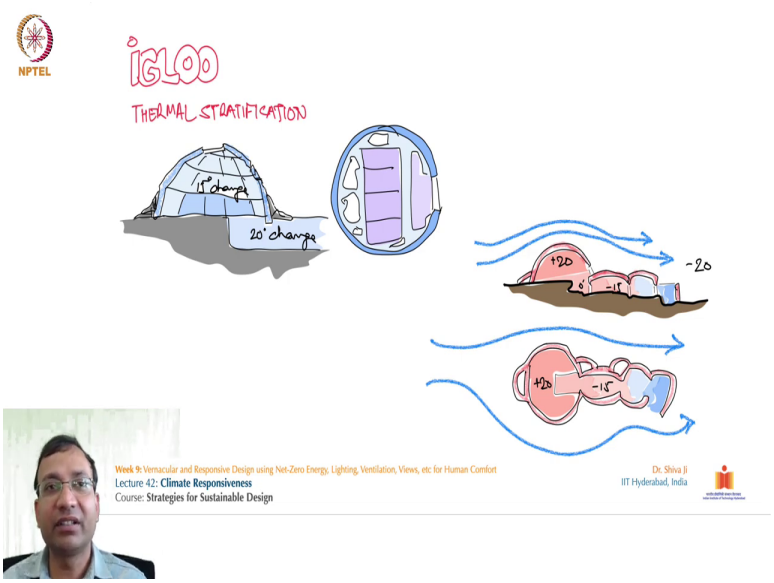

In this example you can see this is the typical cross section of an igloo. So, we are all fascinated with the design and the structure of the igloo since our childhood. And we have seen how the people in this region one of the harshest cool climatic region in world they survived the harshest wind and the cold prevailing winds the climate which is extreme. So, this form of this structure which is made up of the ice itself, the frozen water to create habitable chambers within this shell over here. So, this follows the semicircular structure.

So, this cross section shows this thermal stratification above this ridge platform over here you can see how the temperature is varying in this huge number from here in this chamber it is minus 15 degrees centigrade. And here it is 0 and here it is plus 20. So, this is the significant change in the comfort from this chamber to this chamber over here. And this is how they have laid down the internal arrangement of this structures. So, this is one of the marvelous vernacular architectural systems which has been used by humans in these extreme inhospitable cold climatic regions for several years now.

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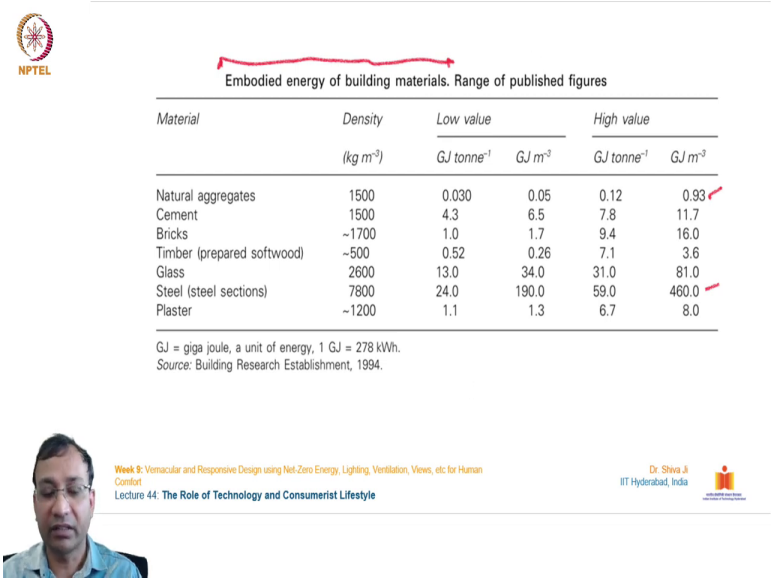

Further we will see how the material plays important role in getting the desired results which we want from structure. And this has been a key element, key slide for us to understand how we can play with the materials in designing our structures in vernacular way. So, if you see this is the embodied energy consumed by different materials. So, if you see the natural aggregates the very natural materials, they minimize they utilized the lowest of the lowest less than Giga joule per cubic meter.

And if you see this cement and the bricks, they are using 11.7 to 16 Giga joule per cubic meter. And the timber actually takes only 3.6 there is a glass takes around 81 and the highest taken by the steel which is 460 Giga joules per cubic meter. So, that much of energy is required to produce 1 cubic meter of steel. So, we can see if we compare, so this is the first value is less than 1 and this value is 460.

So, there is an immense difference from this to this. So, just imagine in the previous lectures we were discussing how we, how the world has whole has fallen in the trap of actually consuming tremendous volume of energy. And how this dependence on energy can be minimized through adopting these strategies. So, the answer is right there, choose the material responsibly which are going to they have in certain way.

So, even if we are constructing modern building so, we should not forget these buildings which are very, very earthen, very, very rooted to a place. So, we must actually utilize then and we can

explore different ways of adopting main into the, our modern building. So, that is the one of the challenges and very, I feel very challenged to use evolving innovative ways and strategies to adopt these low embodied energy materials in utilizing our modern houses.

So, how this can be done? Is I leave it to you, you can utilize these lessons from this lecture from this course and utilize in your design projects and exercises, how well or how efficient you make them by just changing for example just the material part of it? So, instead of using a brick if you use adobe base like bricks or ramped earth bricks. So, how much of energy you can say, how much of embodied energy you can save right there.

And by avoiding steel as much as possible just keeping steel for the structural purposes only, how much we can make, we can bring the difference. So, the answer is right here in this data sheet over here. And the interpretations are up to you to take it ahead.

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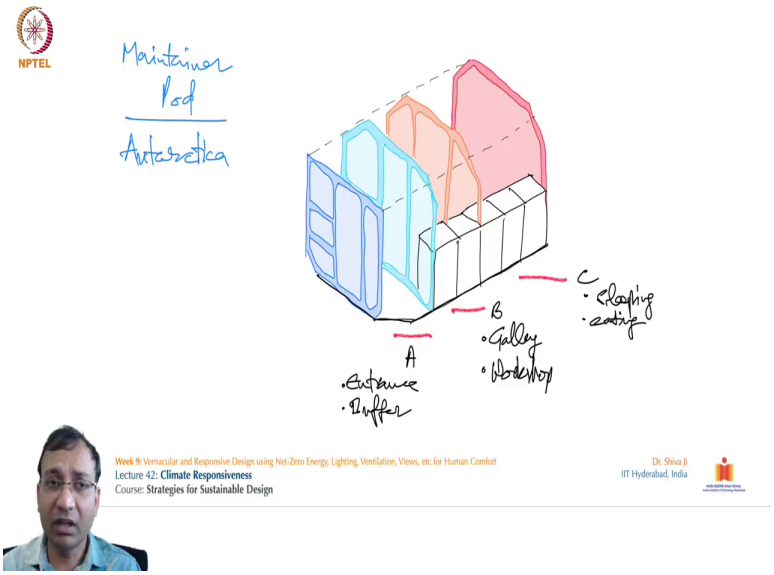

So, another example in very inhospitable environments of Antarctica. How scientists and explorers they have created and designed the modules and the maintainer parts to survive this is in extreme inhospitable environments. So, you can see there are several chambers so, this is, this concept is also, derived from the igloo what we saw in the previous slide over here to have sections have the chambers the multi layered chambers in the spaces.

So, you can see the and this chamber, this is for entrance, ebullitions, ice melting, heavy clause equipment thermal buffers are in the zone A. And the zone B this is there is gallery and the wet

area and the workshops and then in the chamber C there are like communications, eating, terminals, sleeping etcetera these activities are here inner most chamber area. So, this is the modern derivative of the same philosophy and the same approach which has been used in the vernacular system of such places.

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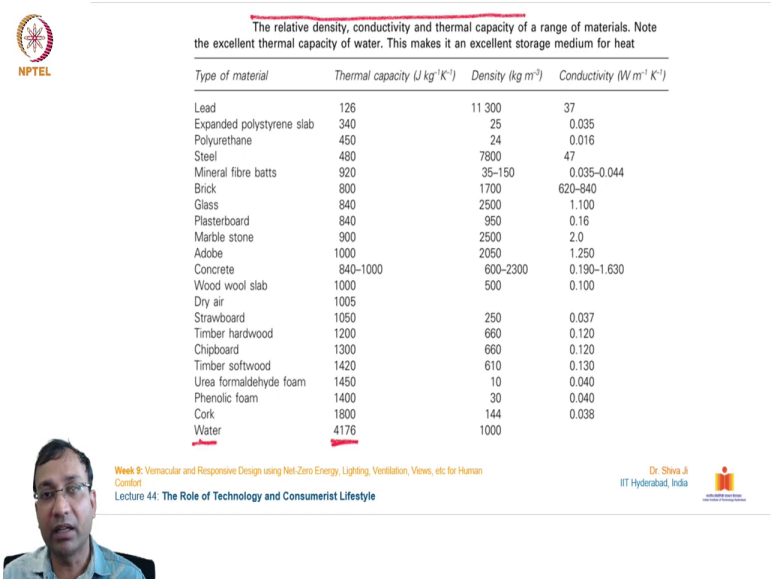

Further on the material part coming down to the material fall. If you see the relative density, conductivity and thermal capacity of the range of materials. So, three things we are talking about here and this is also one of the most important charts and tables for us to be aware of the kind of a materials what we have choosing. And how much of impact these are going to have on our designs.

So, how much of material they are going to use? How much of energy they are going to use? So, by choosing appropriately we can control the wastage of the resources as well as energy. So, in the thermal capacity if you see the lead has the lowest 126 and if you see this water, water has the highest thermal capacity to retain the heat. So, how the water can be utilized as may be packets and the layers to be to work as a buffer between interiors to the exteriors.

So, this is, this interpretation is up to you, some other very familiar materials you can see the brick, brick consumes 800 almost, glass has 840, and then we have cork as an insulating material has 1800 compare to the best actually manmade material of the well cork is also, a natural material but adopted by humans in for the certain usages. So, compare to even this kind of

material you see how much of a plain water has almost the double of this the cork even more than double of it.

So, this is the kind of a potential these are natural material has. So, if what if we use water as a material for a creating the thermal capacity in the structures. In case for example if you want to reduce the heat quotient of our building. So, how efficiently we can utilize the water itself as one material. Further come to the conductivity column over here. So, well lead has the highest conductivity and one of the highest and you see that the highest we can see here lies in the brick.

And this the region, this brick material gets heated very fast and it absorbs the heat very fast and you compare to this you will see all of these are materials which are actually source from water nature, where it is water, cork, this timber soft, they are all, they have this conductivity quotient in fraction. So, well we can choose in proper combination of these 3 values. And we can apply these materials responsibly.

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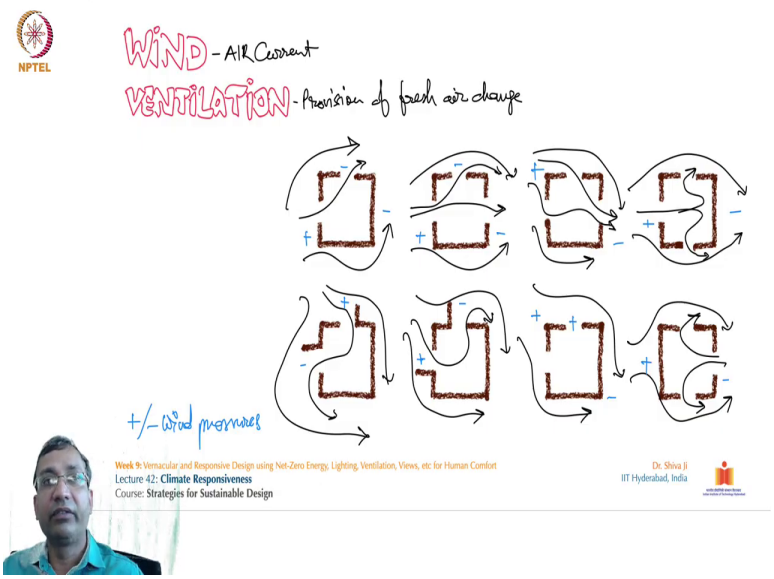

Further to this what could be the other strategies, so ventilation is one of the very important requirements of any buildings. So, how we can plan the openings in our building because there is always some wind. So, how we can even if it is not the wind is not very fast, so how we can create actually high pressure and low-pressure micro zones to induce to the wind inside our premises. So, this slight talks about that, so, how we can promote cross ventilations.

And how we can promote staggered way of wind moment, in case if it is not needed then how we can avoid it. So, in the direction of prevailing wind. We can place our building in such a way that it does not receives so much of air if we want to avoid it. And similarly, if we want to receive wind in the interior quarters. Then we can position our building we can position our openings in such a way that we can take the most advantage of it.

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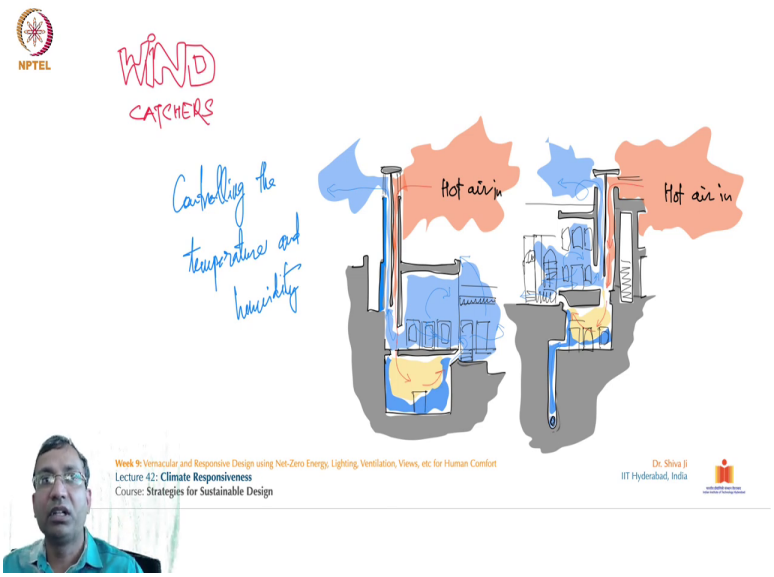

Further to this we will see this slide over here. So, this talks about controlling the temperature and humidity inside the premises of any given building. So, this example we saw in one of the pictures in the vernacular lecture. So, we saw these wind tower, so, these wind towers, the main function of these wind tower is to receive the wind bring it down in the lower quarters of the building. And the while going below the building in the lower quarters this here gets in touch with the colder walls surfaces and even sometime the water element which is flowing below the building.

And then again it rises cooling the temperature in the other quarters of the building. So, this is one of the very interesting techniques which has been popular in the several vernacular architectural system from across the world, even India has some of these examples from dry and hared regions. And several such example are found from the other hot and dry region from the gulf area and other countries. So, these are called wind catchers, sometimes they are called breeze walls. So, this is the phenomena how they work.

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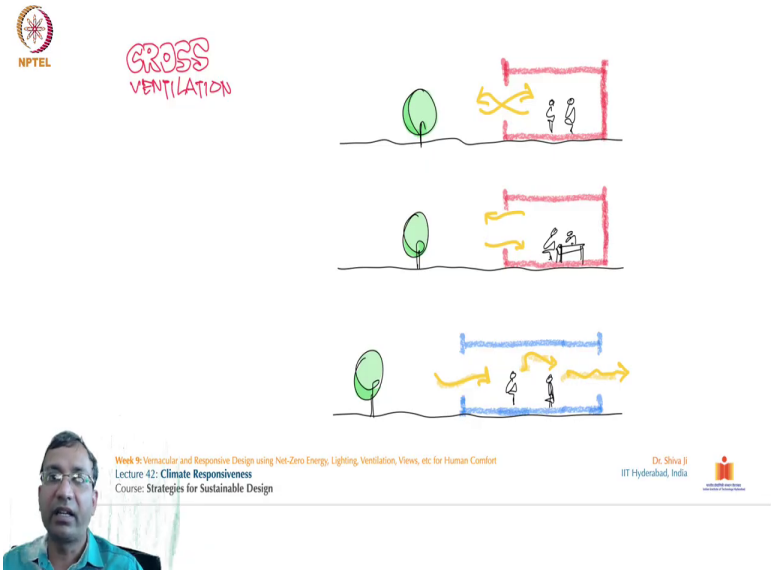

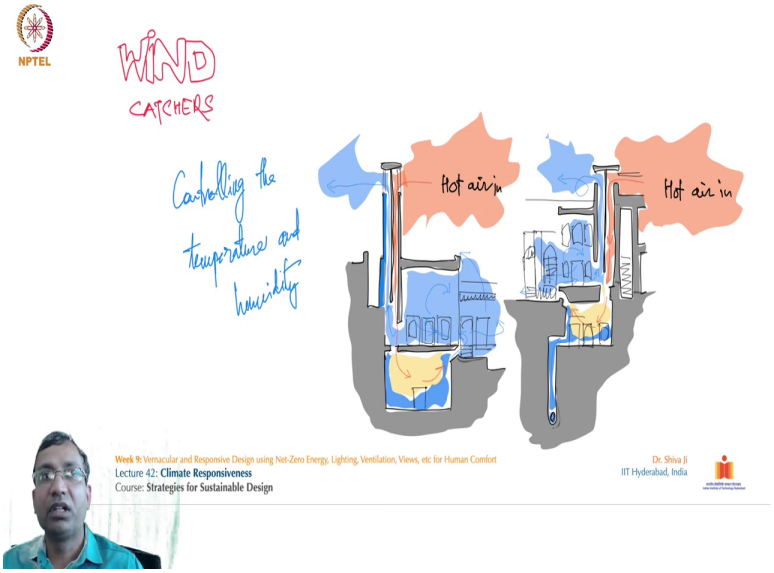

Further continuing our previous discussion. So, in the cross section also, we can plan our openings in such a way the one we saw in this like a wind tunnel wind, breeze wall this cross section. So, similarly we can have even if we are not going to have very tall structures. So, how we can plan the openings the cross section of these openings the length and width of this opening, we can make them vary and depending upon that we can control the passage wind through premises.

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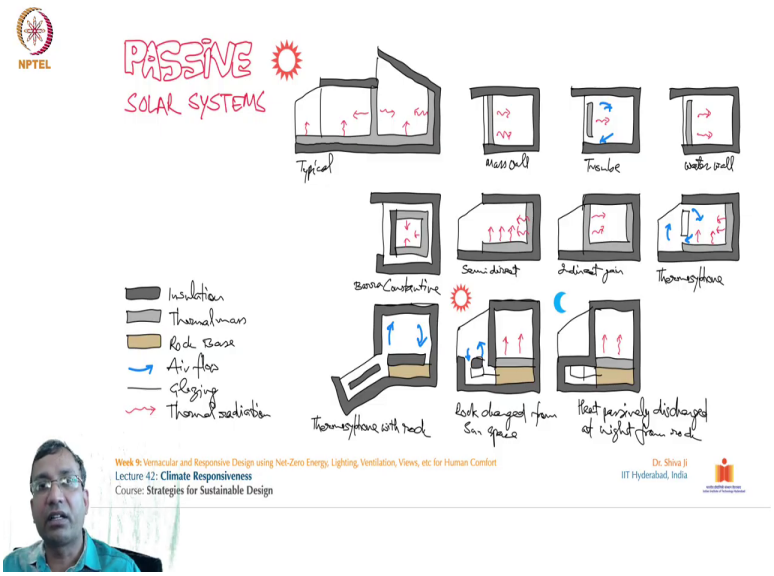

There are several other this, there is a passage solar systems mechanisms which employ the specific materials which we saw in the previous slide embodied energy. And even the conductivity how much of the heat they are going to transfer to the internal quarters. So, depending upon this property we utilize these materials in different combination whether how much of heat we want to allow on interior of that space and how much we do not want to.

So, it is a combination of different materials in different cross section you can see over here. This is known as typical passage system where in some portions we are allowing the heat inside you can see the material region over here. This line represents blazing and this represents insulation this one a thermal mass. There is a blinds, there is a air flow and the thermal radiation. So, you can see over here this material of thermal mass is going to have some radiation inside the, these quarters.

So, we can allow these such kind of openings over here which can penetrate inside the spaces and similarly you can see all of these examples, how this heat and the conductivity can be controlled by applying such materials. In this combination you can see how the same cross section is going to behave in day and night. So, that is also illustrated over here, this is rock bed charged from the sun space during the day.

And this only heat passively discharged at the night from the rock bed. So, this rock bed it absorbs heat in the day time it releases heat in the night time. So, that there is a balance

temperature in the internal quarter. So, this is one the important slides where we talk about choosing strategies for our designs.

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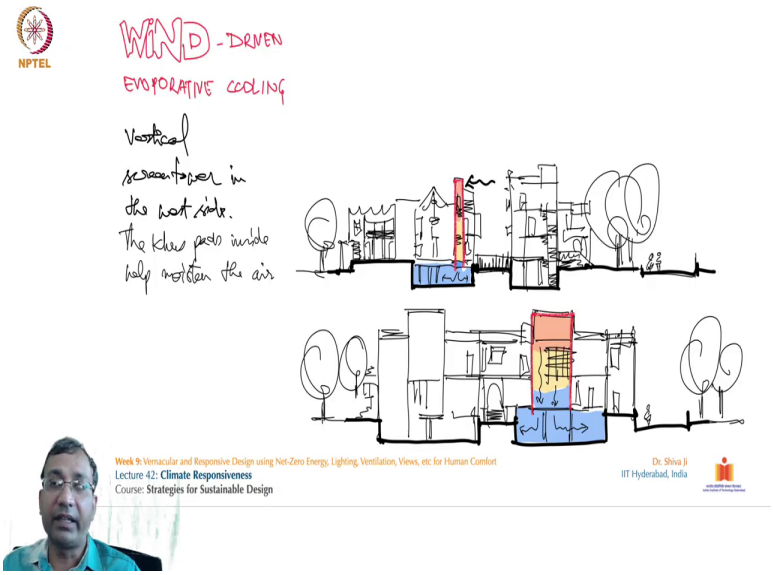

Further to this in the wind driven evaporating cooling this technique there are some more examples in this area, even utilizing the vegetation at what distance they should be, what height of this trees should be to have shading effect on the building creating buffer zone of air, creating cooler ambient temperature here on the, in this vicinity. So, utilizing the prevailing wind directions in hot dry seasons. So, these are verticals screen towers, these are winds tunnels work as a evaporating units. Sometimes they use *khas* lining also to create fragrance, beautiful fragrance of this water above this air inside these premises.

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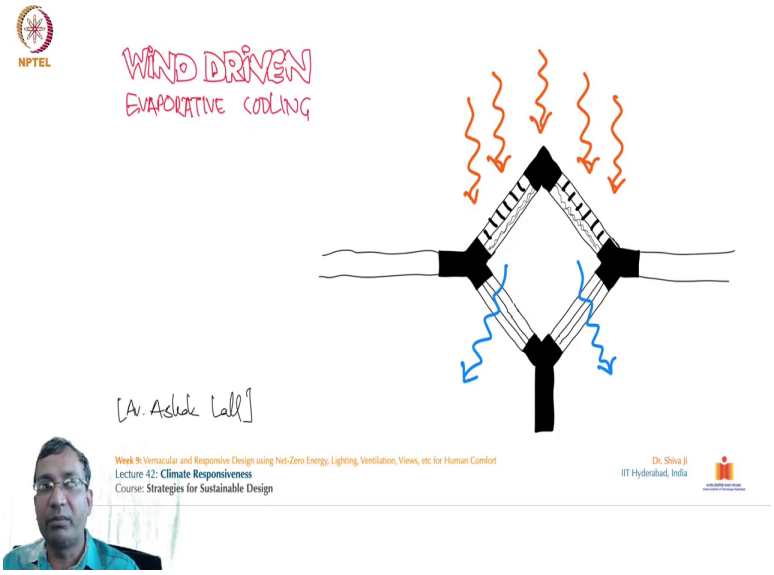

Further some recent in the recent times, recent few decades there are some examples used by several architects from this age also utilizing the vernacular principles. So, you can see by Ashok Lall how he has utilized this *jaali* as a screen as a filter to reduce the temperature from outside to the indoor quarters. So, obviously there will be some reduction in the temperature of the air while passing through this chamber.

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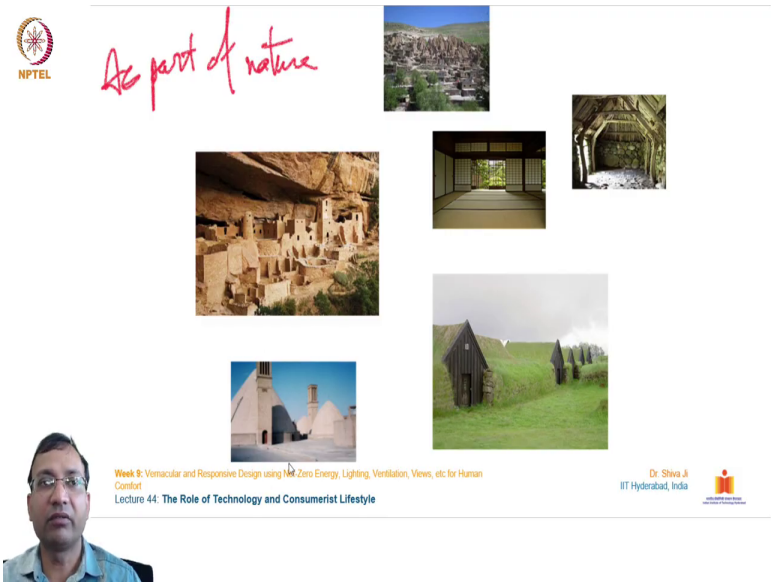

You can see here are some examples from different countries how the vernacular designs they have been part of the nature itself. You can see over here this does not looks manmade roof but the natural grass surface has a gone top of these houses. And some more examples over here you can see these Jain quarters from japan and these are wooden and Thatch roof utilizing the stone for these retaining walls here.

And these are structures which are carved out of this is stone blocks. So, the rock cut architecture and even they have utilized the stone and the other brick material also in the along with this stone. So, as this combination of rock cut as well as manmade structures. And these are wind tunnels and wind towers.

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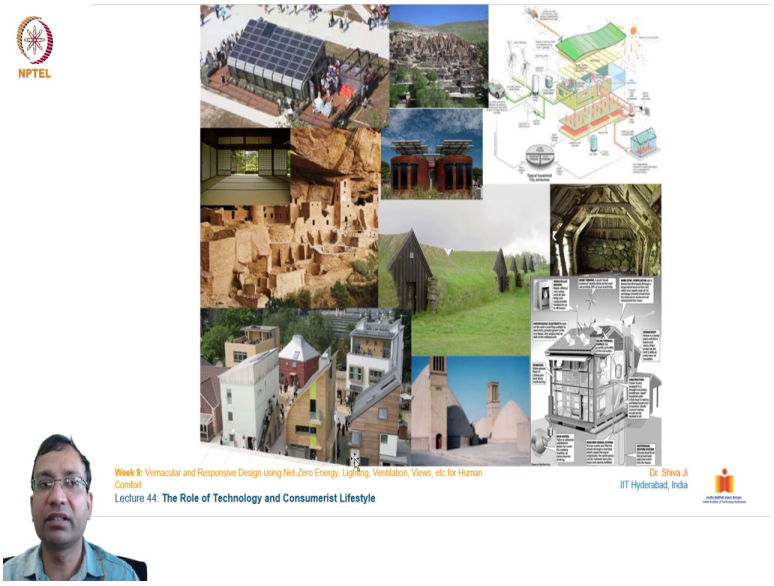

And in the recent times if you how these adoptions have been done. So, utilizing mechanical methods how is use electricity-based solutions to control temperature, control humidity, and the wind directions. So, combination of these if you see how the integral these examples are with climate. So, depending upon the need of the climates, so these arrangements are made to how we can harness the solar energy at these places where there is a plenty solar exposure available around the year. And how we can go in sync with the landscape and the topography, how we can go for ventilation through these methods' mechanism and things like that.

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So, some more strategies how we can plan the openings on the building surfaces to restrict the summer duration sun which is very harsh and hard. And we can permit the winter duration sun inside, so that we can get some warmth in the colder months. So, such arrangements are very typical very common I am sure you may be already aware of such strategies. But I am reminding for our understanding and these small details also sometime we keep forgetting. So, these play very important role in our design and choosing strategies.

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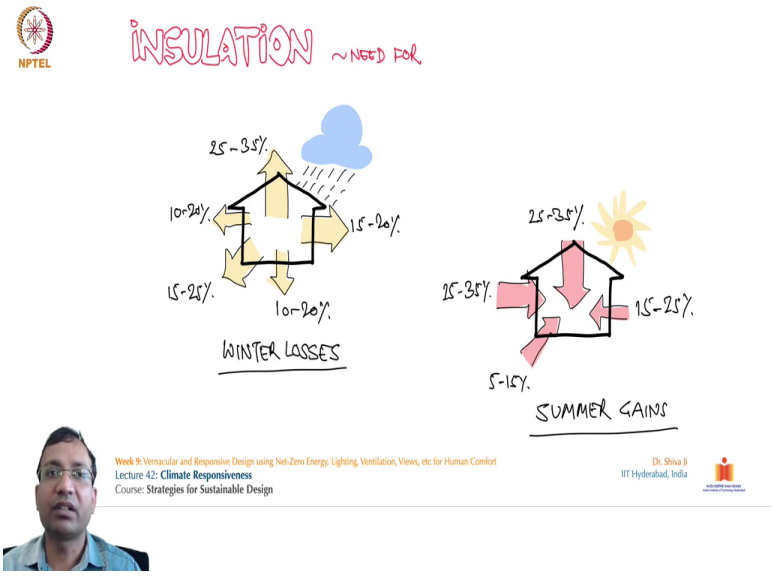

Other dealing with the temperature changes how we can create insulator, the surface insulating material on the envelope of our building to reduce the heat exchange how we can plug the holes and gaps and other leakage points to check the leakage or the fill there are n number of material commercially available in the market today for thermal insulation. So, we must choose them depending upon the uses and application. And while doing so we can minimize the consumption of energy.

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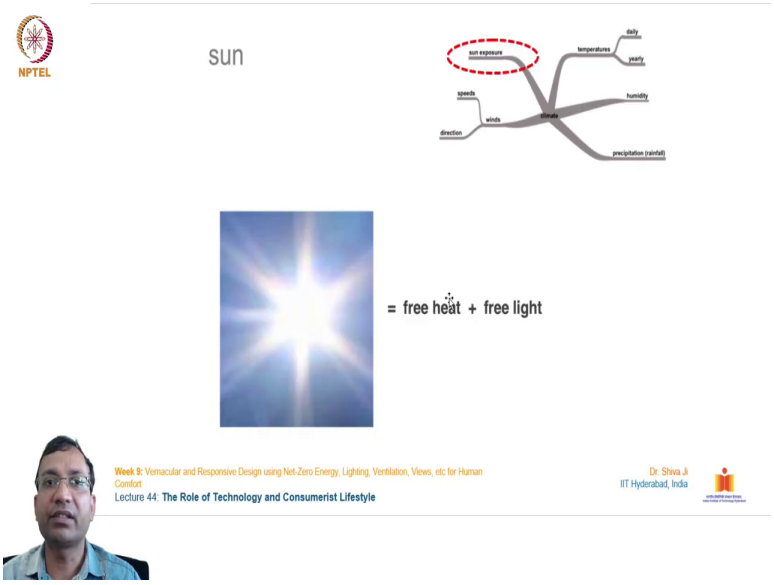

Further sun gives us free light, free heat. So, how well we can utilize and, in those months, when we do not want how well we can avoid it, so by choosing strategic methods.

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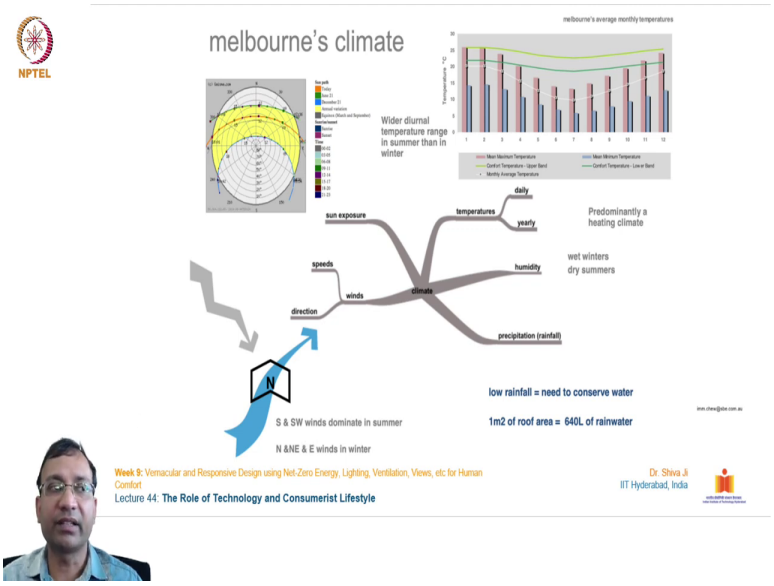

So, you can see this is a chart climatic chart of the city of Melbourne in Australia. So, this talks, this gives a comprehensive picture of this temperature, monthly temperature over the year. And this talks about the solar exposure and the angle at which the sun is going to be in this particular place and then the prevailing wind direction. So, this the chart you can prepare for your own city also, your own town also, as you can keep it handy for your design needs.

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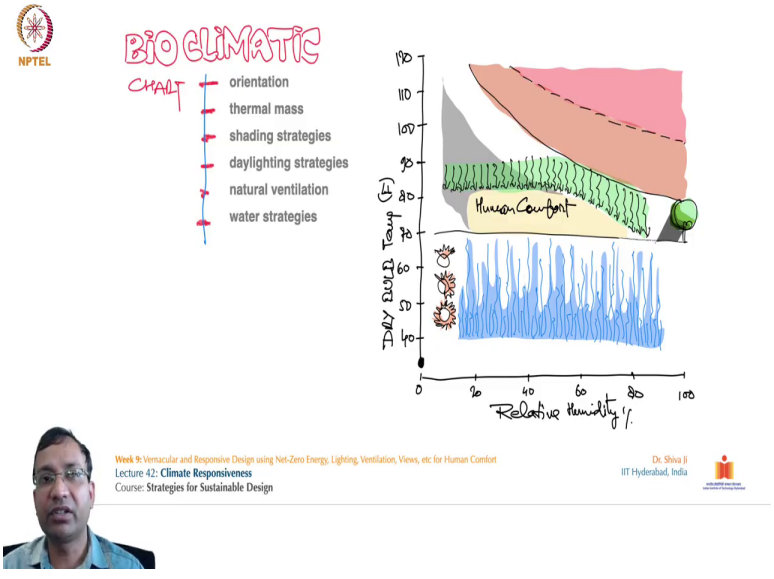

Further there could be several strategies, several responses strategies for climate related responsiveness in an overall sense. So, that could be depending upon the orientation what we had discussed earlier. Thermal mass based on the properties of the material, shading strategies, day lighting strategies, natural ventilation, water strategies also, how water can be utilized in creating ambient temperature inside the living quarters.

So, there is this comfort zone, human comfort zone. You may refer the climatic chart of your own place and you can look for the comfort zone what the set of the temperatures, what are the set of relative humidity and wind speeds are needed and for comfortable, creating a comfortable climate condition for the humans.

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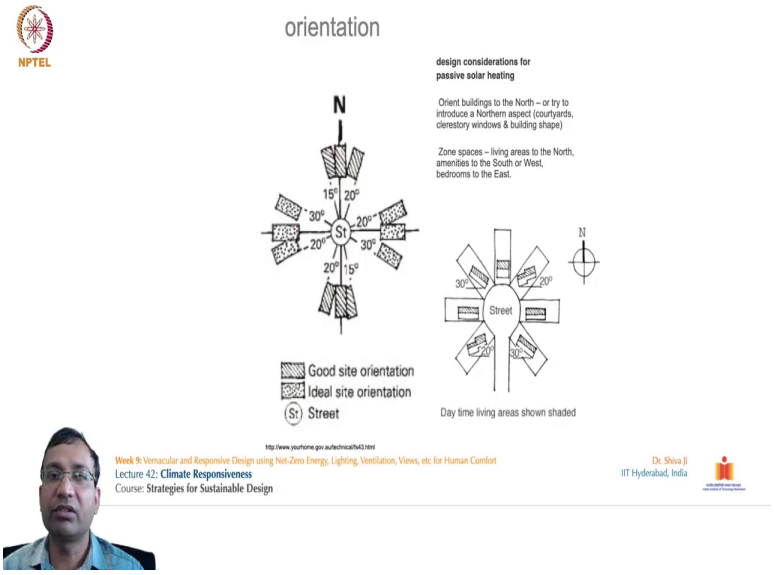

And accordingly, you can imply. So, this is the, an example from the Melbourne itself how the site, how the building location as has been given over here. So, you can see this region and the so, this is the good site orientation which is facing actually north and south. And this is the ideal site orientation which is facing east and west. So, there is actually a combination which must establish between the prevailing sun direction, prevailing wind direction. And the other natural features on any given site.

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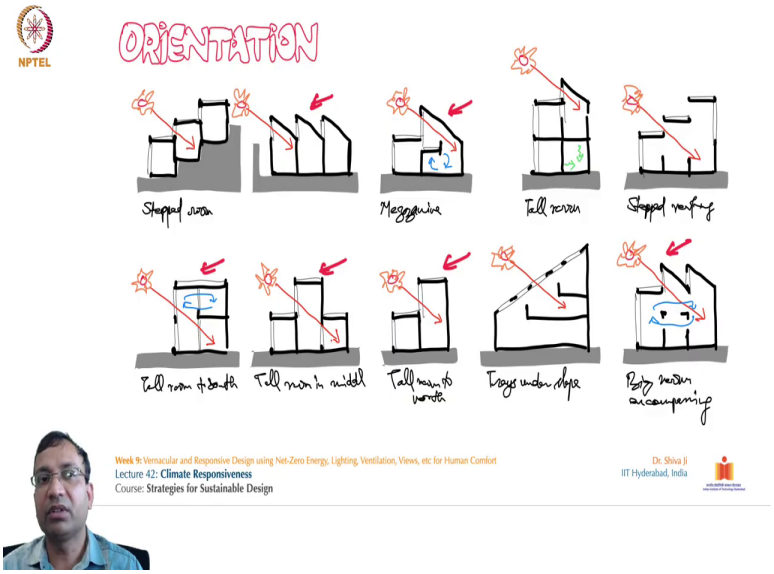

This illustration talks about the orientation like how well we can allow the sunlight to get in. So, several kinds of solutions are possible well they depends on the site conditions also, which suits the most or maybe we can go for devising our own innovative ways of adopting with these strategies.

So, this is the staggered way of keeping the spaces in a layout or maybe changing the roofing angle of it or maybe utilizing a combination of it may be going double height with it. Maybe creating entire roofing in on very staggered manner. So, there could be n types of solution possible in different conditions and the depends on the topography of the that land.

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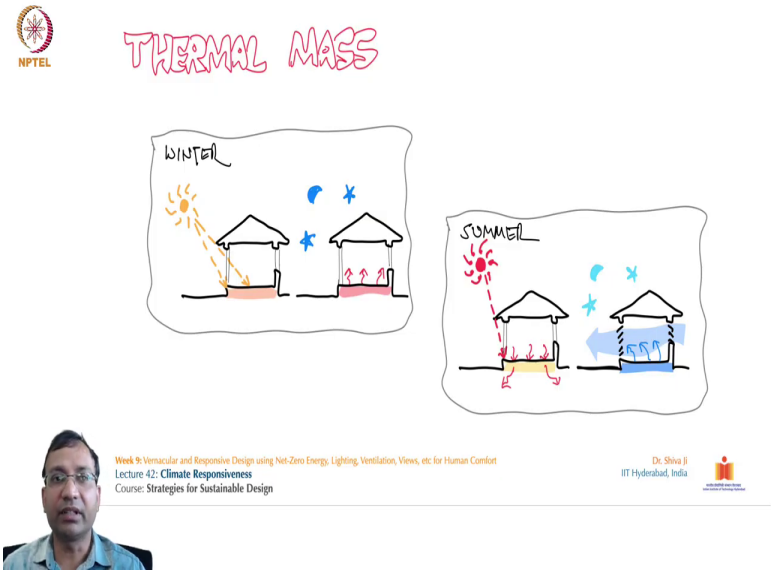

For the thermal mass we have already discussed how we can use, how we can utilize materials which have varying thermal mass capacities to best out of our advantages in our designs. So, whether it is a stone, or maybe, mud, or adobe, or brick, or steel, or maybe any other material how responsibly we can response to that particular climate the prevailing climate of that pictorial place.

So, that is the challenge, that is strategy what we need to adopt. So, you can see over here this fiberglass insulation has the lowest thermal mass capacity of only 9.2 kilo joules per cubic meter kelvin. So, and with this if you see way water has the highest capacity. So, when we need such kind of situations where we need to have the requirement of the thermal mass maybe we can go for these materials from the top water, granite, concrete, sand, stone, and clay tiles etcetera.

Once we do not want maybe in those places, we can go from the bottom up. So, this aerated autoclave concrete you can see AC blocks over here, this has 550 kilo joules per cubic meter kelvin, this thermal mass stores capacity. So, this is one of the preferred materials in the recent times which utilizes the industrial waste output of this fly ash in creating in making bulk of this are AC blocks.

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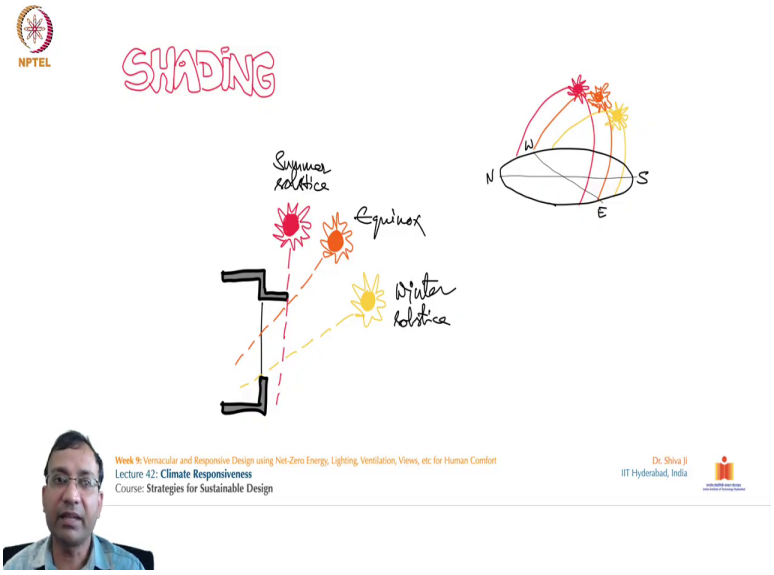

Several other strategies and combination in the planning in the plan in the section the previous one we saw in the section over here in this one and this one. And here we are discussing in the plan so, how these are staggering and these other lay outing techniques we can utilize. They depending upon the activity areas and their requirements. So, we can choose insulating materials also on the surfaces which are going to be exposed to the sun other those stronger natural elements.

Shading one of the very important strategies for design, how well we can avoid sun when we do not want it and how we can permit sun inside when desire it. So, there are n number of solutions available for such myth, technique. And this has been used in the vernacular architectural systems traditionally and there are several other mechanical solutions also in the modern times to control the sun.

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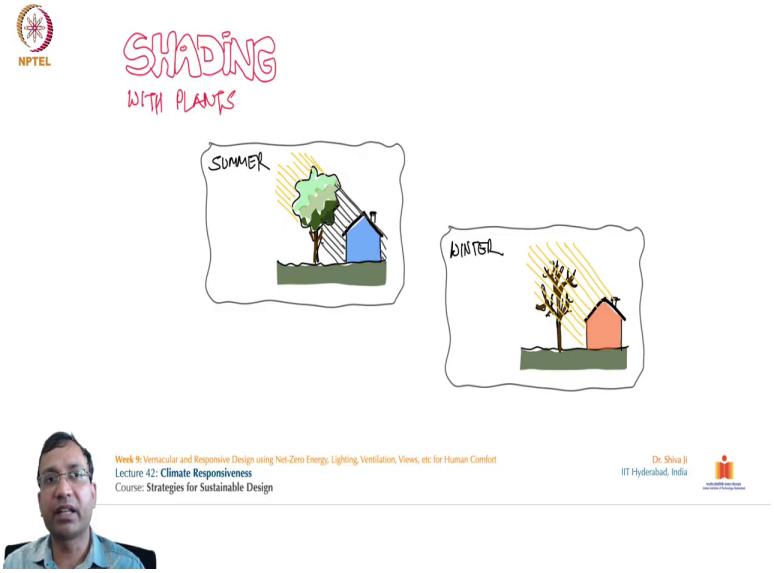

Yeah, shading with the plants also, because plants are one of the very important elements which absorb the sun's heat. So, we can utilize the location of the plants how far we should keep them from building surface at what distance and what height is desirable of these plants or these trees should also be taken into account for this act designing a responsible climate responsive technique.

So, we can utilize these residues plants which remain green over the year depending upon the requirement. So, very self-explanatory illustrations are given over here which will help you understand these phenomena.

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Well traditionally also, how day light strategies have been used you can see in this sketch. So, this window plain is opened to allow the sun at this point of time. And when it is not needed this can be closed and the opening will be closed.

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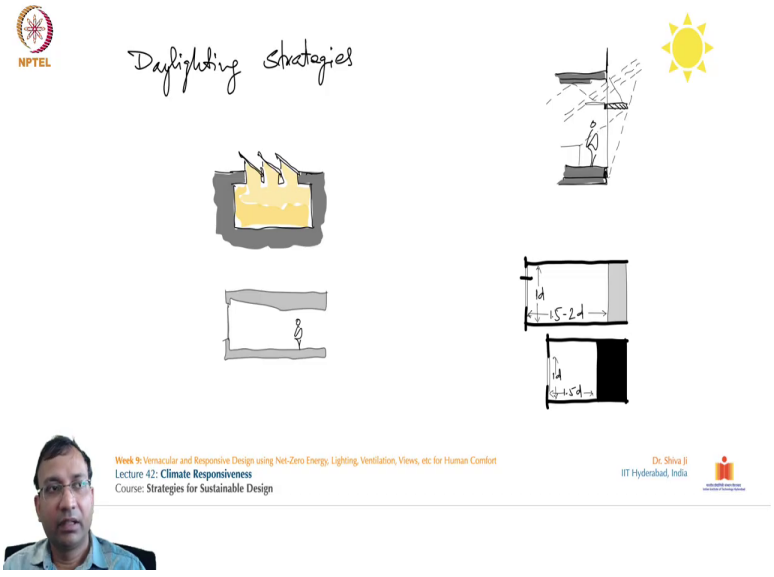

Well daylighting strategies how we can bring in the natural sunlight inside our premises. So, there are several surface treatments and detailing are available in for different climatic places. So, depending upon the location and the site these strategies should be utilize. So, the window to

wall ratio (WWR) and the depth of the spaces the screens and the angle of these louvers these are all part of the overall study area.

So, you can see in this particular sketch over here. This day lighted June is a up to 2D which is the height D if D is the height, then daylighting can go up to the 2D comfortably but beyond that it will be little lesser. And in the other time of the year, it could be only up to 1.5 D and this inner quarters may be relatively much darker situation. So, how this can be handled in these two configurations you can see how this is bringing this change. So, just with the change of this the louver over here in this cross section of this window. They very so much of difference we can absorb in the overall resultant.

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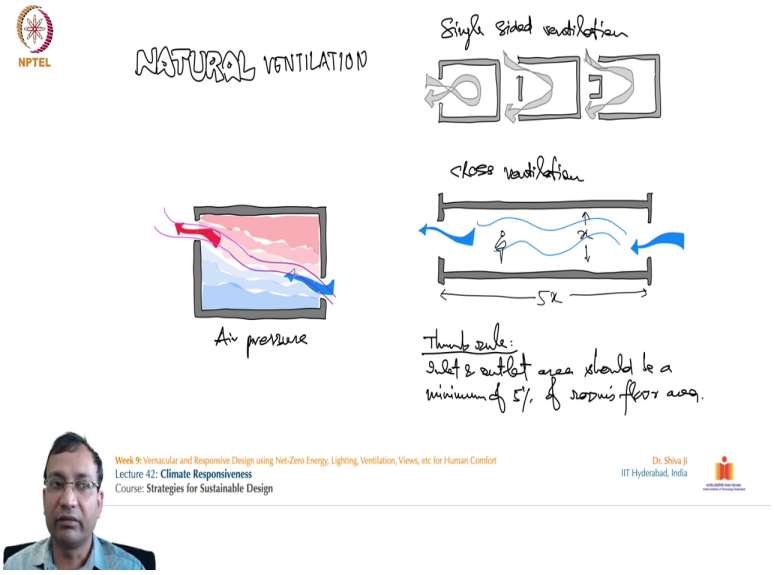

Further for the promoting natural ventilation. So, we have some solutions over here how we can devise openings, how we can propose if the openings in the building structure to control the wind or control the flow of the wind inside our structures. Another strategic location of the inlet and outlet points also should be decided because if we want to have scouring effect of wind inside the space to have the maximum effect may be the location of this entry and exit points could be at the diagonal level. So, that will maximize the overall efficiency of this further cooling effect.

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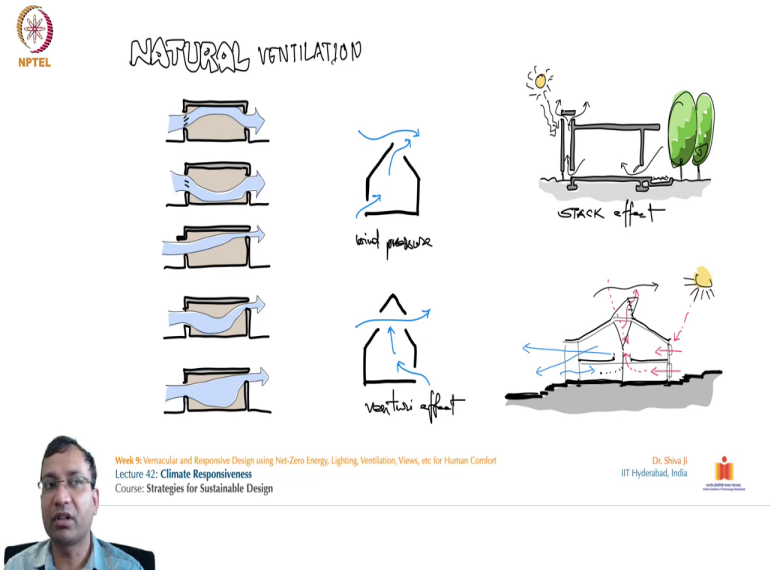

Well some more explanations from different cross section how this hot air can be allowed to take exit from the building. So, this has been traditionally as well as you can see in the recent times with the recent advantages. How this has been, this is being done in these buildings by using such fins or the top of this structure. So, this gathers this collects the all of the stake air and it releases in the air from this top most portion of in this building.

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Similarly, for the water and cooling light effect how these upper bolas and other sun shade devices can be installed in which parts of these buildings and these can be maximized for the efficiency. You can see here the double roofing treatment is given to have to minimize the overall heating at the bottom floor. So, there is a buffer area of air only because air is one of the best materials for this thermal insulation. So, this air is also naturally trapped over here creating a buffer zone. So, these are techniques are utilized in number of places in the world how they have achieved and maximized efficiency by using the natural means of it.

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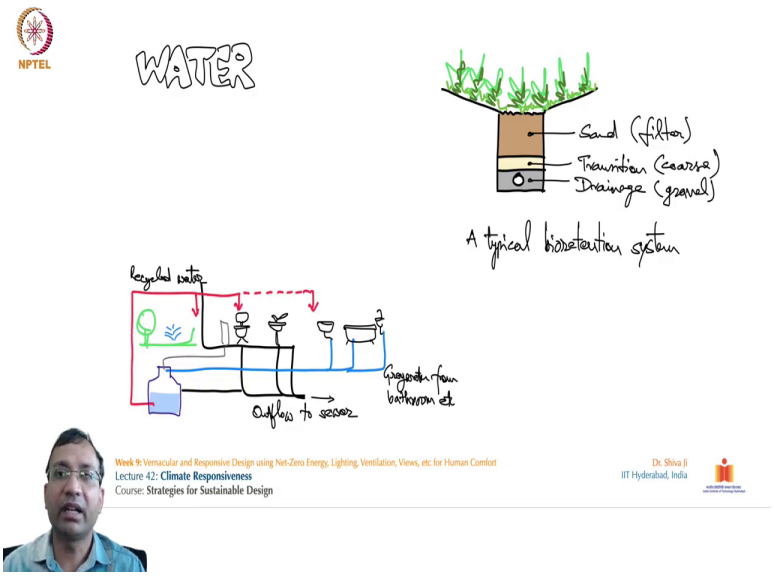

So, this is where this climate responsiveness and this philosophy this strategy comes for the rescue even this water, so how the water column so, water walls and such the other things can be utilized for example rainwater collection and the same thing, the same water can utilize for others site related activities as well as creating a temperate area creating humid area if there is a need in the arid place.

So, water also, can be utilized for creating such ambient atmospheres on any given site. So, these are the n numbers of strategies which we saw in this lecture. Which are directly related in the climate and the climate responsiveness. So, maneuvering through them maneuvering with the help of these would result us definitely in a positive way because this has been tried and tested over centuries. And the examples we have already seen in the vernacular architectural lecture.

So, this is one of the most efficient and less impacting ways to go for sustainable designs. So, you must keep them in mind and you can always be innovative and creative to devise your own ways of dealing with it. These are not limited, these are not exclusive, these are not your learning is not limited to these only you must explore beyond these and you must go ahead in terms of explanations and coming with the new solutions with this I would like to bring an end to this lecture. Thank you everyone.