Energy Efficiency, Acoustics & Daylighting in building
Prof. B. Bhattacharjee
Department of Civil Engineering
Indian Institute of Technology, Delhi

Lecture - 07
Introduction & Environmental Factors (contd.)

So, these are the three climates as we are talking about main climate hot dry desert climate, warm humid climate and composite climate I will come to them and I was talking of Mumbai which has got less daily variation. So, monthly mean maximum and minimum we have been plotted here.

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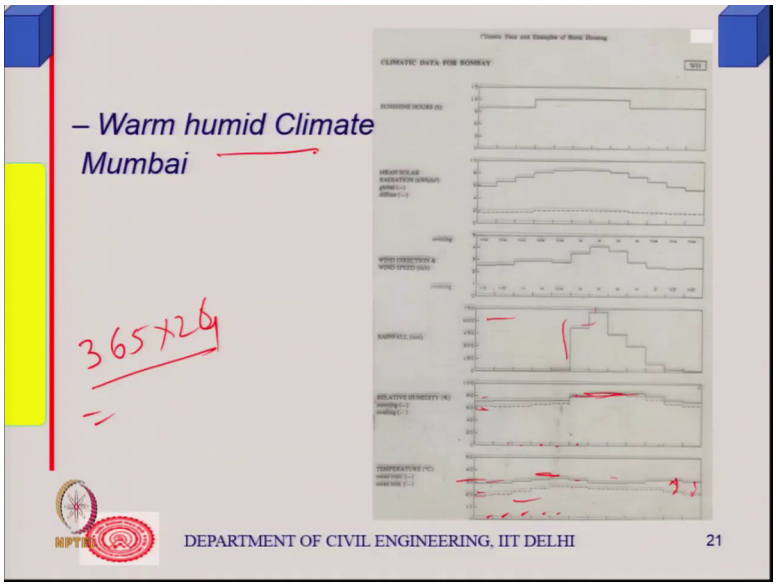

You can see this variation is not much really it would be order of around 5 degrees or so, 5 to 7 degrees I have more details of this. The relative humidity of course, the here 90 percent most of the time in the month of February, March, April, May, June, July, August etcetera etcetera you will have high humidity all the day, high humidity all the day you know and lot of rain fall this is the precipitation. So, you will have 600 700 and 50 here. So, huge precipitation during that period of time and you know it is humid.

So, the name is warm humid climate, warm humid climate right. Indian code of course, classified in slightly different what I am trying to tell you the principal first then I will come to how Indian codes EC BC energy code in India or national building code classifies them. They do it in the same manner.

Also you will see that wind direction because its during the monsoon period wind also will be high and direction will be coming from the Arabian sea side Southwestern you know it is called southwest monsoon, am I right. And in Tamil Nadu of course, during the winters is so called winter season they also get a rain fall that is northeast monsoon because Tamil Nadu and those areas because you see 8 degrees is a Thiruvananthapuram or somewhere around that is 8 degree. So, you are very close to the equator right which passes far away somewhere through Sri Lanka Addis Ababa and all those you know that line right. So, tropic of cancer in that area there is a heating up of the ocean water. So, moist air will go up similar thing which happens in summer the northwest monsoon that kind of air movement moisture movement takes place in December. Australia for example, the summer is sometime you know what is our during our winter period because sun has gone to the southern hemisphere right.

So, the moisture comes and then when it heats the Eastern Ghats there is a precipitation in the Nilgiris and Eastern Ghats on the eastern side of it they will be precipitation on those side. So, they have October etcetera etcetera they have rainfall during those period of time. So, that is also warm humid scenario.

So, you will find precipitation then wind direction is dependent on that wind direction prevailing wind direction will be dependent on that. So, in Mumbai you will find high wind during this similar time and then you have sunshine period, sunshine hours right. So, sunshine hours because cloud cover sunshine hours will be daytime is longer, but cloud cover etcetera is also important. So, this is how actually mean solar radiation is here how much is the solar radiation on a horizontal plane direct and the diffuse this diagrams are given.

So, one can give a diagram of this kind to represents the climate of a given place.

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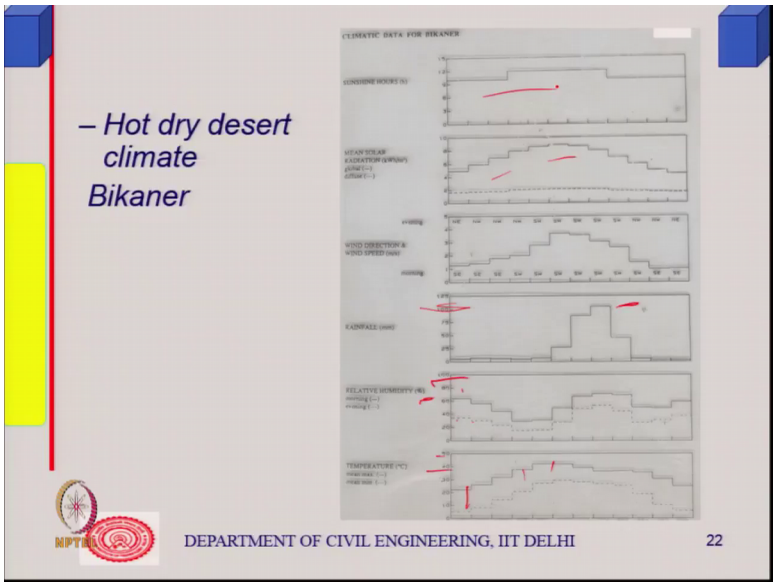

Similarly, hot dry climate which is Bikaner receives very little radiation as I said I mean sorry rainfall because precipitation you will see the order is around 100 maximum sorry precipitation is 125, rainfall is you know and Mumbai it was 750, scale was maximum 750 it does not practically does not receive wind radiation. Relative humidity is much maximum is 60 it can go as low as 35 or so, maximum relative humidity in a month of May, April May it can go much lower and minimum humidity still lower early in the morning. So, humidity range is not between you know 35 to 60 and sometime it is between 40 maximum is forty minimum is 35. So, very dry situation.

Temperature is much higher here you see the scale is up to 50 Mumbai the scale was 40 perhaps somewhat less temperature was here this is this was 50, but this never went beyond 40. So, this is characterized by and this gap is also larger you can see this gap is also relatively larger that was 5 to 7 degrees here it will be about 10 12 degrees or even more can be more. So, rainfall is less, wind direction prevailing wind comes desert wind there are there is something called like you know they call it locally [FL] dust storms. So, you find dust storms in part of the western and northwestern India even northern India here also it is to come.

Now, of course, lot of greeneries that has reduced down and then mean solar radiation is relatively high and sunshine hours is also 8 10 hours during the summer months that is

Bikaner the desert you know desert basically hot dry desert climate also sometime we call it.

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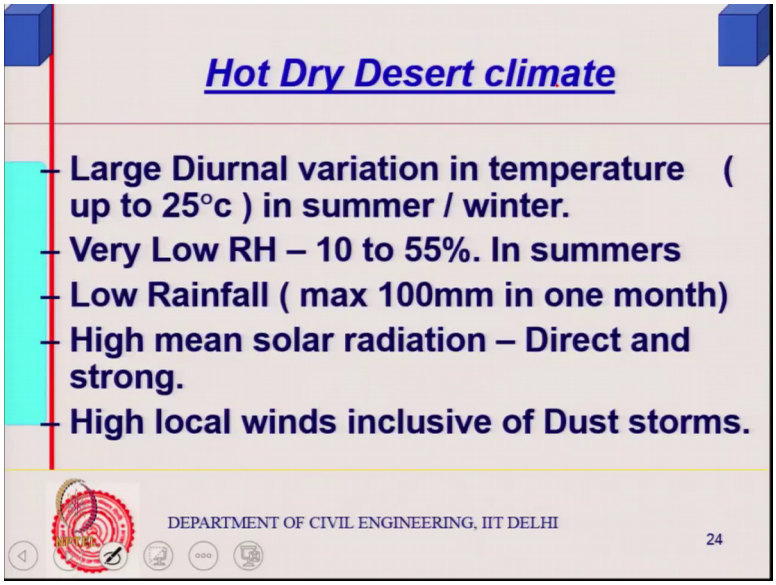

Then large diurnal variation of temperature up to 25 degree in summer or winter. So, daily variation can be as large as this very low humidity 10 to 55 percent in summers low rainfall maximum 100 in a month and high mean solar radiation direct and strong and high local winds inclusive of dust storms during the summer right, warm humid yeah fairly high sunshine hours 9 to 12 hours low vegetation.

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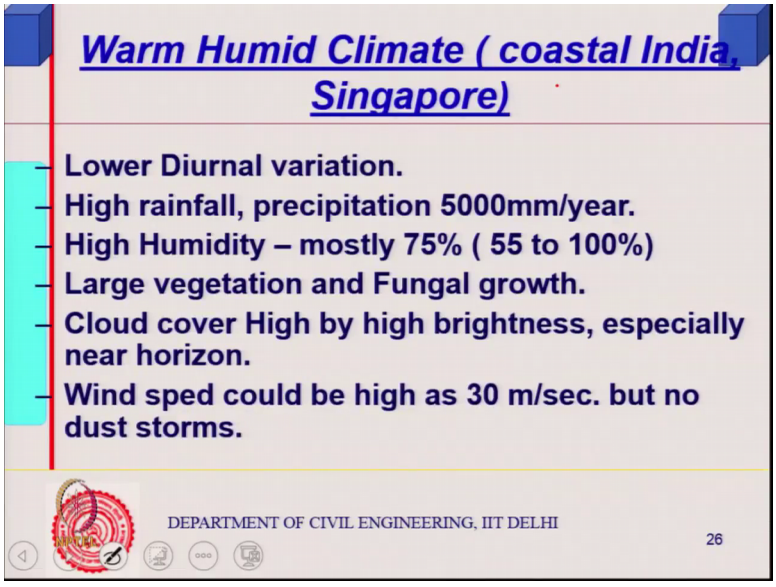

The reason why I am the written ones are coming right. Now, I did not discuss about the composite climate as yet. So, usually clear sky brightness of the sky is very high and near horizon is very bright near horizon is very bright. Warm humid climate what we have seen lower diurnal variation daily variation is less 5 to 7 degree that is what I said in Mumbai, Coastal India, Singapore these are examples and examples of hot dry desert climate examples are not given, but Bikaner is one of them I given. Then high rainfall precipitation can be 5000 millimeter per year, high humidity mostly 75 percent 55 to 100 percent. Mumbai you have seen during the rainy season it is near 100 percent all the time anyone coming from Mumbai you can realize this right.

Cloud cover high, high brightness especially near horizon and wind speed could be as high as 30 meter per seconds, but obviously, no dust storms there will be no dust storm lot of greeneries lot of greeneries. Now, when I say composite monsoon climate composite climate or composite monsoon climate, it means it is composite of the two both features are there. So, composite monsoon climate you will have some hot dry months some hot dry months, some months warm humid and some months cold dry period as well.

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Now, this is because of Himalayan scenario. For example, if you consider North India North Central India you have a dry summer right, but as soon as the monsoon comes the rainfall starts, monsoon comes because during the dry period ocean you know the

moisture the moisture bearing air from the ocean will move northwards they will come in terms in contact with the cold air in the mountain and precipitation it would occur and therefore, this precipitation essentially changes the temperature lower heat down, but increases the humidity. So, you have a hot dry season which is because of the tropic of cancer and you know tropical zone where sun raises very high, but then after once the monsoon comes there is a dramatic change temperature comes down rainfall and humidity increases rainfall is there and humidity increases. So, you have a summer period and then you have a rainy season period which is like one humid.

Summer season is almost like desert scenario and then you will have a cold season also small cold season also. So, variable sky condition directional winds because you have got you know its mixture of both its mixture of both. So, basically you will have some summer season, dry summer season, some warm season warm humid season and a little bit of cold season. So, its mixture of wall that is why we call it composite and it is actually largely controlled by the monsoon scenario. So, we call it composite monsoon climate right. So, this is, this is it.

So, diurnal you know hot dry maritime is a sub climate. So, that is the main climate sub climate. The sub climate of the hot dry desert climate also for example, city like Karachi right anything in the desert area, but close to the sea shore that gets modified because of the humidity that comes from, but not as much as the one humid. So, its dry relatively drier it is somewhat you know it is very humid and temperature does not get as lower as warm humid. So, usually hot dry maritime climate is diurnal range is relatively less high humidity, but high temperature also. So, most of the features are with the hot dry desert climate sort of, but there is a humidity is higher. In fact, this can be extremely uncomfortable scenario.

So, you know the places say located to the seashore in the Arabian Gulf desert area, but close to the seashore they can be very uncomfortable of course, unless you are sitting inside an air conditioned room all the time. So, then fine then there is something called tropical island climate which is upland climate which is at high altitude the climate would change because solar radiation received would be less temperature is somewhat lower as we have seen also earlier in our earlier discussion and they have diurnal range is relatively high, high relative humidity precipitation is somewhat higher and those

altitude wind velocities high due to trade winds and many other character is similar to warm humid climate.

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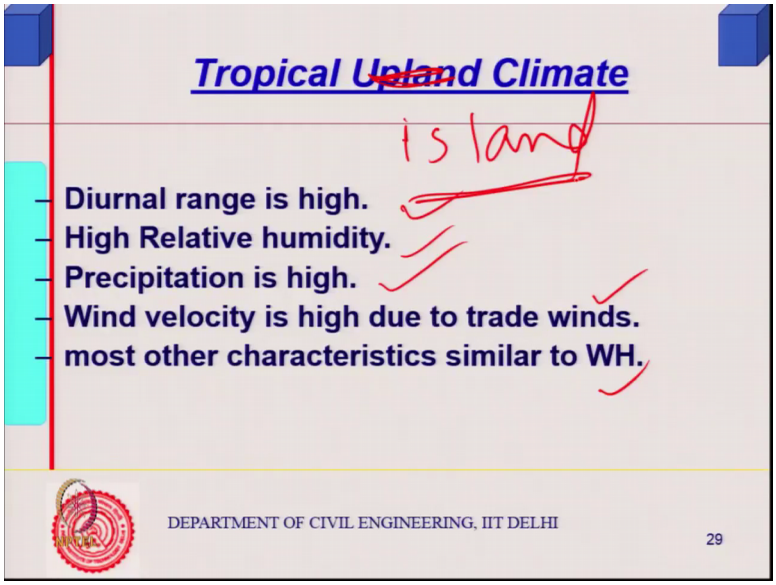

This is I think island climate no this is not correct this is island climate tropical island climate, this features are for tropical island climate high relative humidity, high precipitation tropical island climate. Singapore, West Indies, Philippines many of them exhibit this kind of climate where you have actually there in the warm humid zone, but because surrounded by seashore. So, when a location which is otherwise in the desert, but close to the seashore it becomes maritime desert climate, when it is warm humid otherwise, but close you know surrounded by sea all the Andaman for example, in India. So, there they are you know that temperature would come down precipitation will be really very high and that is called tropical island climate.

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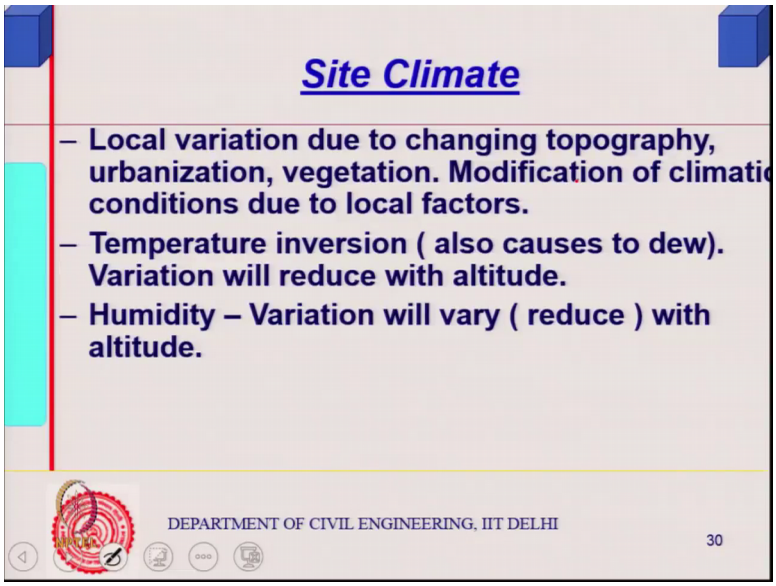

Upland climate is somewhat modifications that bring down the temperature. So, altitude in tropical areas also like you know places like they moderate the climate. So, you have places like say Ooty in Nilgiris or even Deccan many places that temperature is much lower Pune, Bangalore, their temperature is somewhat lower they get moderated because of their altitudes or situation of the similar kind you know surrounding effect of the surrounding. So, these are the climatic zones, these are the climatic zones. This gives you rough idea.

Now, according to the climatic zone you can design or plan your building, but with today with advent of modern computational capability you know the thumb rules are not really not so important and also the style of building styles have also changed because you want to house a lot of activity a lot of population into a single building right.

So, the basically you know that the even living style has change may be 200, 300 years back it would be in 2 story, 3 story building only I mean one two story building only not even three maybe even 4 5 storey building did not come because the lift was not there till Mister Otis actually showed that a lift is safe in 1832 or something, in US 1832 I think if the year may not be correct nobody was ready to make anything beyond 3 storeys. But today things have all changed and therefore, you know thumb rules are not so important, but you must understand. So, climatic understanding gives you what type of for example, if it is a hot dry desert sort of climate you know the humidity is less right.

So, planning of the building would have been good old days they would have planned it with a courtyard. If you see the traditional housing in Indian scenario you go to Rajasthan say Ajmer, Jaisalmer those areas you will find also locally stones are available thick walls would use thick walls traditional I am saying and thick walls would store the heat during the daytime because diurnal variation is very high and morning it becomes relatively cold outside. You know it may be a little bit you would like to cover yourself up or something of that kind. So, that time large thermal mass of the thick stone walls would radiate it inside, it will store the heat radiate it in the morning or later part daytime it absorbs late night it would be actually transmitting. Traditionally by experience people have actually designed planned building like this and you will find courtyard type of building with a small kind of a you know water pot there because they do not have too much of water.

So, water pot there which they use for you know it will be evaporative cooling and there various other kind of passive system traditionally people have used to get thermal comfort right. So, that was according to the climate. But you look at northeastern India or Kerala you will find very thin wall gable roof to shed off the rain because lot of rainfall, like lot of bamboo construction in the Northeastern India for two reasons one you do not need to store the heat what you need is lot of air movement relative humidity is high usually. So, you would like to cool by taking away the moisture vapor from the skin. So, therefore, lot of air movement lot of open areas and since rainfall is high you will find pond here and there lot of water bodies you will find and then you know I am just quickly telling you the traditional housing would have used that kind of concepts of the climate.

Also interestingly northeast India it you know it is in earthquake zones 5. So, seismicity is very high therefore, lightweight construction help there. They would you know construction will match with the requirement traditional housing, but they were all one storey two storey today you want to change them there has ever been a change. So, engineered system has come in and, but such thumb rule of wall requiring high thermal mass in hot dry desert climate requiring lot of ventilation or fenestration as we call it fenestration is the area opening left in the wall by design required in warm humid climate that possibly you do not require this thumb rule, but still it is a good understanding you should have.

Then one if is an engineered building then you can obviously, use your mathematical tools the software and the physics and everything put together and, but the thumb as you know climatic variation has got some relevance. So, to that extent it is fine, but otherwise you would be you know numerically you would be able to design the system or calculate at this kind of thing. So, design is more it can be more formal and systematic.

Now, coming back to site climate, this is climatic zone site climate is associated with local variation site climate is associated with local variation for example, if we know like if we pave the area too much the surface runoff will be too high which means the evaporation loss from the ground will be less. Too many concrete building will store the heat and temperature of an urban area can be at least as much as 8 degree higher than a similar area where there are lot of greeneries. So, these are called site climatic changes.

If I have tall buildings that will block the air movement that will obstruct the daylight light coming to the you know sudden maybe some areas become shadow. So, these are site climate. So, local variation due to changing topography, urbanization, visit vegetation modification of climatic condition due to local factor we call it site climate atmospheric science people call it micro climatic variation, temperature inversion also do occur for example, during daytime you know suns radiation falls onto the ground and you have higher temperature near the surface by the afternoon. In the night surface radiates the heat the temperature of the surface becomes cool where somewhere at the top some height small height above temperature remains same.

So, temperature this is the phenomena of temperature inversion near the surface there is a change from high temperature to low temperature from day to night. So, humidity variation also it varies with altitude and so on. And construction of tall buildings can disrupt rainfalls etcetera etcetera as I said because for example, if the monsoon direction is from east to the west and you have tall buildings in the eastern side of the urban area there can be orographic effect or rain shadow. But in a larger scale for example, you might have heard of Mawsynram, Cherrapunji where there is a highest rainfall in the world, but Shillong the rainfall is much less because Mawsynram is on the southern side of them heels of Meghalaya. So, the monsoon rain coming through the Bangladesh, I mean monsoon wind coming through the Bangladesh hits the Meghalaya and precipitates there majority of it, but Shillong is on the.

Student: Northern side.

Northern side. So, it is actually a rain shadow area you would get much less rainfall you do get rain fall much more than; obviously, the desert area and those, but compared to Mawsynram Shillong is much less. This thing can happen in an urban area also tall buildings can block reduce down the rainfall pattern in some other places. So, this is called site climate solar radiation mutual shading of one building by other. These are taken care of in urban planning these are taken care of in urban planning, this ideas must be there.

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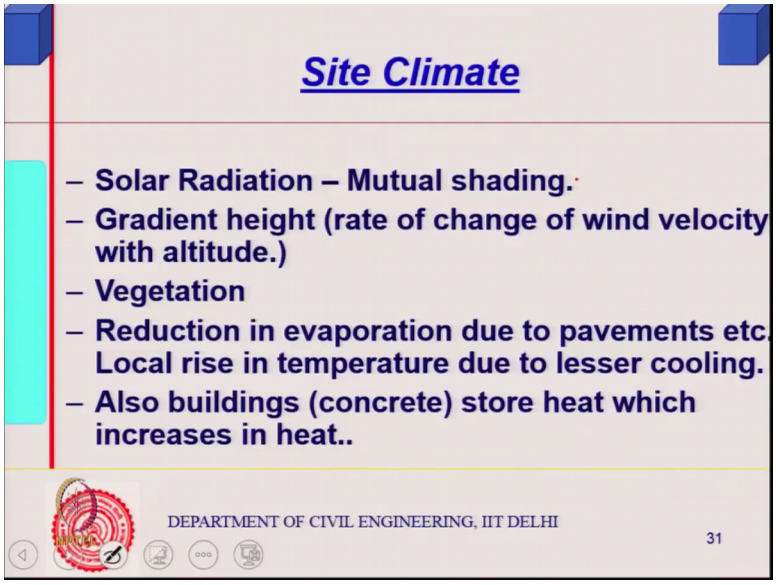

Gradient height as we said you know temperature I mean velocity wind velocity it increases with the height and radiant height changes. Topography if it is all rough gradient height is more if it is plain radiant height is.

Student: Less.

Less. So, that is it.

Vegetation would change for example, vegetation would increase the humidity right even in a desert for example, Jodhpur city of Jodhpur after the Indira Gandhi canal has come it has become somewhat green. So, temperature will not close to those canal area it has reduce down, but humidity has increased. So, that can kind of changes could occur.

Pavements reduces the evaporation etcetera local rise in temperature due to laser cooling this is a site climatic effect. Also buildings store heat which increases the temperature also you know heat capacity of this masses thermal masses. So, what is very difficult to take into account all this site climate because it is not very easy to take into account, but we must have some idea. I mean one can do we know future somebody will do the modeling, but then what is going to happen tomorrow how it is going to change you do not know. At the current state of affair there are some modelings available and people are trying to do, but this on the research area. So, you have to actually take into account all the buildings that is there and with possibly you know satellite map you can find out how many buildings are there some people are trying to do research on those urban heat island as is called and so on. So, is still in research stage, but site climate do modify. So, when you have planning a new building designing a new building some idea related to the site climate should be there with you.

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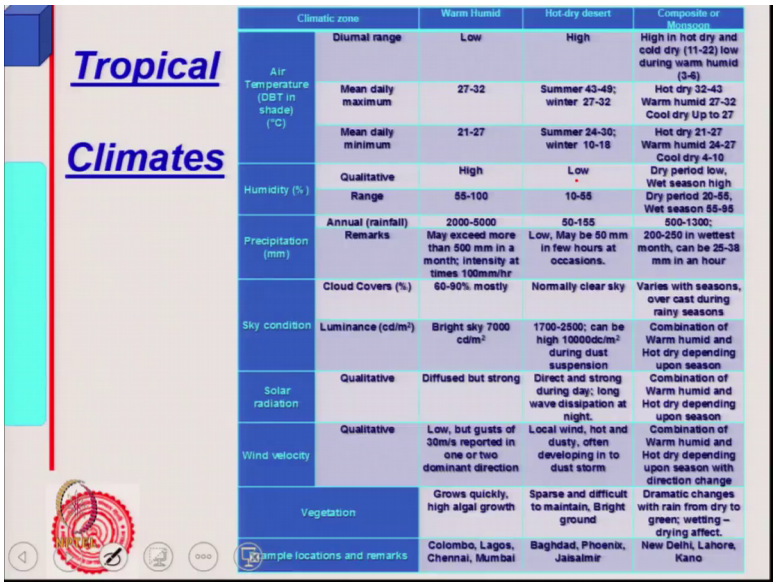

So, tropical climate as you see summarizing this air temperature if you see in this table which you will be able to see of course, not in this screen I am not very sure how much it is, but whatever I said is summarized in a table like this see mean yet you know if I look at the air temperature warm humid climate diurnal variation is low. Hot dry desert diurnal variation is high diurnal range is high. Composite monsoon high during hot dry season and less during warm humid season. Air temperature mean daily take maximum temperature is generally ranges are given 27 to 32 in warm humid, but in summer in hot

dry desert can go up to 43 45. Libya Tripoli 50, many of those you know Pakistan cities Jacobabad district have very high temperature I do not know it is still the highest temperature where temperatures go high.

In New Delhi it goes to 42 43 easily, in somewhere in Jaisalmer it will go to 47 48, many of those places do you know those areas the desert it could go 42 40, you know 43 49 range and winter may be much less 27 to 33, 32. So, see the variation seasonal you know yearly variation is also high.

Then hot dry season in composite monsoon climate you will have high maximum temperature and warm humid season you will have again similar as warm humid climate because composite is always mixture of the two. So, it will have both the seasons mean daily temperature maximum minimum is usually close to the mean daily maximum and in case of hot dry desert climate winter it can be pretty low. Again composite this is a mixture of the two, humidity in warm humid climate it is generally high 55 to 100 and hot dry desert it is less composite again mixture of the two. Precipitation usually high in warm humid climate 2000 to 5000 in hot dry it is 50 to 155 much less annual I am talking of, and monthly also sometime it can exceed more than 500 in warm humid climate, but in hot dry desert climate it is much much less, composite again mixture of the two.

Sky condition luminance usually very bright sky in hot dry desert climate and somewhat you know I mean bright sky in you know usually both the scenarios hot dry as well as warm humid climate cloud cover would be there in case of warm humid climate. Solar radiation diffused, but strong and here also direct and strong in case of hot dry desert. Wind velocity low usually, but they you can have in warm humid climate during monsoon season if you can have storms and there you can have hot dry climate you can have dust storms during the dry summer season. So, vegetation grows quickly in warm humid climate does not you know, does not grow because of moisture is not there if you supply moisture it will grow quickly there too.

Examples of warm humid climate are Colombo Lagos, Chennai, Mumbai, Kolkata many of them in India coastal India hot dry desert for phoenix in US, Arizona that is a desert area you know Southern United States of America is again all tropical climate because it is a very large country. Northern side is subtropical Canada border and all those central

and then Mexico is again tropical and just above Mexico it is all tropical climate because similar latitude as you know like for example, Dallas and Delhi same latitude. Phoenix also would be almost similar maybe slightly south. So, that is (Refer Time: 25:32) this.

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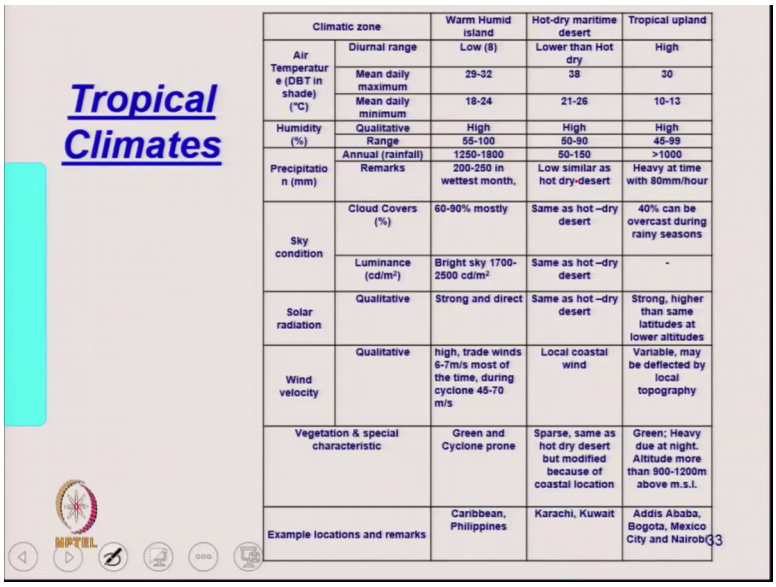

Climatic zone		Warm Humid island	Hot-dry maritime desert	Tropical upland
Air Temperature (DBT in shade) (°C)	Diurnal range	Low (8)	Lower than Hot dry	High
	Mean daily maximum	29-32	38	30
	Mean daily minimum	18-24	21-26	10-13
Humidity (%)	Qualitative	High	High	High
	Range	55-100	50-90	45-99
Precipitation (mm)	Annual (rainfall)	1250-1800	50-150	>1000
	Remarks	200-250 in wettest month,	Low similar as hot dry-desert	Heavy at time with 80mm/hour
Sky condition	Cloud Covers (%)	60-90% mostly	Same as hot –dry desert	40% can be overcast during rainy seasons
	Luminance (cd/m²)	Bright sky 1700-2500 cd/m²	Same as hot –dry desert	-
Solar radiation	Qualitative	Strong and direct	Same as hot –dry desert	Strong, higher than same latitudes at lower altitudes
Wind velocity	Qualitative	high, trade winds 6-7m/s most of the time, during cyclone 45-70 m/s	Local coastal wind	Variable, may be deflected by local topography
Vegetation & special characteristic		Green and Cyclone prone	Sparse, same as hot dry desert but modified because of coastal location	Green; Heavy due at night. Altitude more than 900-1200m above m.s.l.
Example locations and remarks		Caribbean, Philippines	Karachi, Kuwait	Addis Ababa, Bogota, Mexico City and Nairobi

So, that is what it is climatic zone you know subtropical ones are also given in this table same thing I just mentioned the same. For subtropical I mean sorry sub climates like warm humid island climate modifications are given in this table hot dry. Maritime desert climate there again the modification is lower temperature humidity is high and tropical upland climate modification due to the altitude. So, that is again captured in this once and if I look at an Indian scenario this is what is important.

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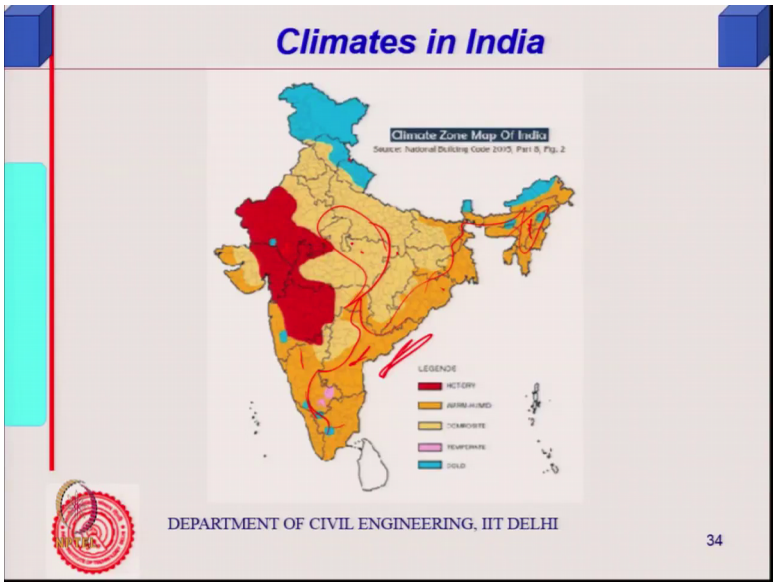

The red one is hot dry desert climate you know red one is hot dry desert climate you can see part of the Rajasthan, part of Gujarat part of the Maharashtra also belongs to hot dry desert climate. The blue is of course, cold because the Himalayan scenario right it is cold and dark yellow this portion this portion dark yellow this portion all the coastal areas and northeast this is warm humid. This warm humid right this warm humid and this is what is composite monsoon right. So, this is not dry some season influenced by this some by this some might be because of this. So, majority portion in the north and central India is composite monsoon climate right.

So, what you do actually how do you classify? First you look into the data and if for 6 months if the pattern matches with the hot dry you call it hot dry desert climate. For 6 months it matches with the warm humid climate you call it 6 or more months warm humid climate, but it does not matches either of them leaving the cold ones that is composite monsoon climate like 3 months warm humid, 3 months hot dry that is you know. So, that is all it. So, that is given here.

Let us say hot dry summarized mean monthly values temperature above 30, relative humidity below 55, precipitation below 5 these are a mean monthly values actually and number of clear days in a month is above 20.

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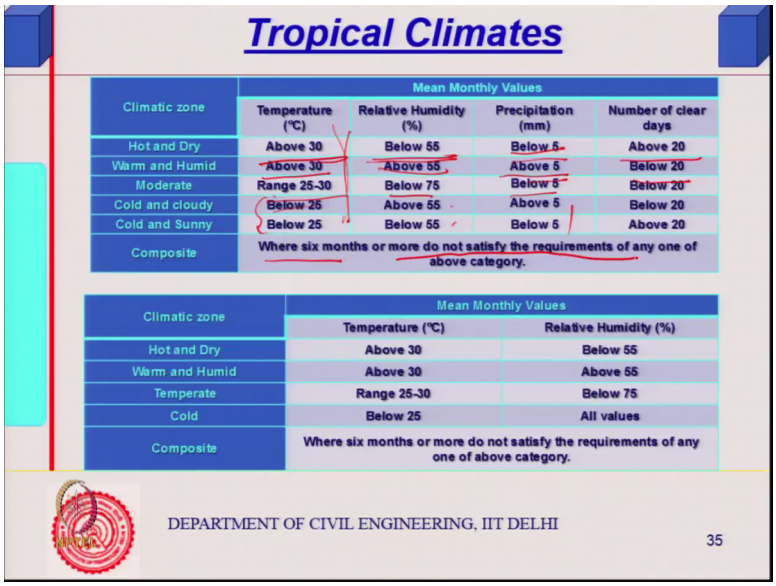

So, monthly data you can have from that you can find out in warm humid temperature mean monthly temperature is above 30, relative humidity is above 55, here it was below 55, this is above 5 again precipitation this below 5, this is 5 and below 20 the cloud cover is very much there.

So, moderate is somewhere 25 to 30 below of etcetera etcetera. Now, when nothing matches with any one of them and cold climates are temperature mean monthly temperature with below 25, relative humidity is above 55 or below 55 and if it were 6 months or more do not satisfy the requirement of any one of this above category that you call as composite monsoon composite monsoon. So, that is what you can collect the data and you will find out. This is again same thing is shown where 6 months more not may not so, basically from two characteristics you can do temperature and relative humidity. High diurnal variation, high maximum temperature, daily variation is large maximum temperature for many months low humidity that is hot dry desert. Less diurnal variation, high humidity maximum temperature is also relatively low that is warm humid climate and 6 months do not fit into any one of them then you call it composite monsoon climate.

So, I think with this we will like to conclude will come to thermal comfort in the next class, will come to thermal comfort in the next class discuss. So, climate I have discussed, climatic features I have discussed, next class we will have thermal comfort.