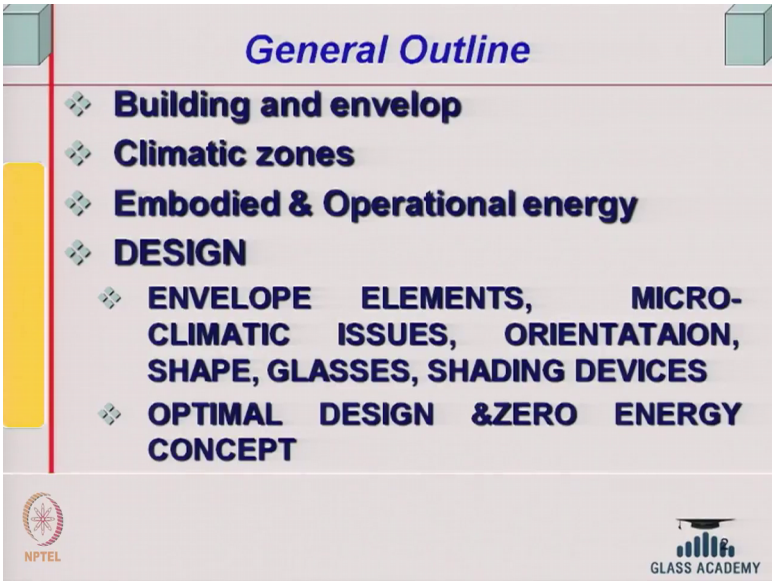
Glass in buildings: Design and Application
Mr. Bhattacharjee
Department of Civil Engineering
Indian Institute of Technology, Madras

Lecture - 08
Structural Control and Design for Energy Efficiency Part I

Greetings from Glass Academy. Today, we are going to you know deliver the I mean I will be delivering a lecture as a part of Glass in Buildings - Design and Applications. My lecture is on Structural control and design for Energy Efficiency: Selection of Envelope. We will look into selection of envelope, orientations, shape and glasses and shading devices.

(Refer Slide Time: 00:57)

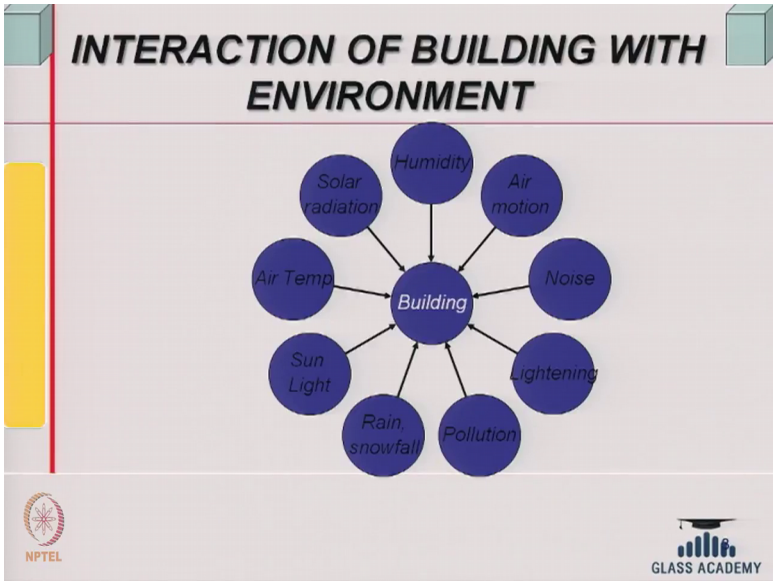


So, a little bit of general outline building an Envelope, we will talk about. We will also talk about climatic zones of India because this part class is a part of a pheasant and therefore, in you know pheasant interacts with the surrounding.

So, the climatic zones become important and when you talk of energy efficiency climatic zone is also important. Therefore, we will just introduce that to you. We will also talk about embodied and operational energy. Then we look into Design like Envelope Elements, little bit I will touch on microclimatic issues although not really this part of Envelope; but microclimatic modification changes the you know modifies the climate a

little bit quickly you look into it. Orientation, shape, glasses, shading devices and lastly optimal design, zero energy Concept including day lighting.

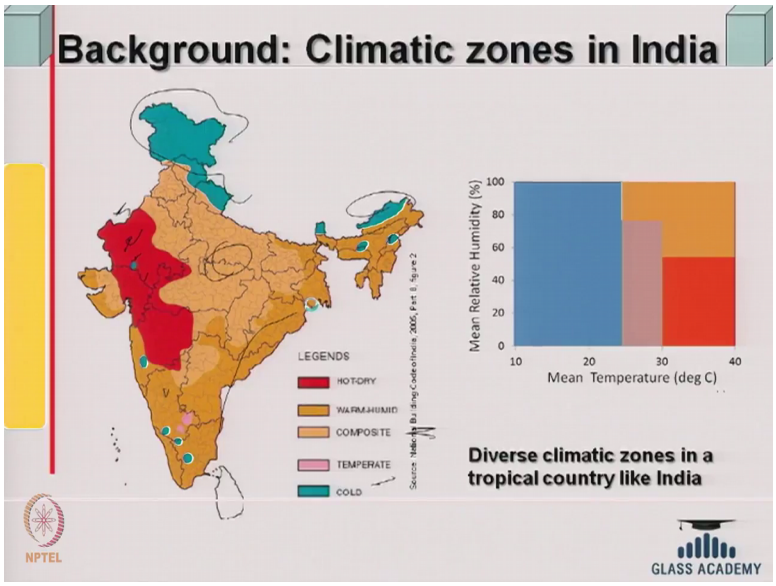
(Refer Slide Time: 02:08)



So, you know first let us look at how does building interact with the surrounding environment? Now, if you see that, there are the building interacts with the surrounding environment and the features of the surrounding environments are humidity, air motion, noise which is of course largely man made, lightening during thunderstorm, pollution again coming largely from manmade scenario, rain and snowfall were together we call it precipitation. Then, the sunlight, the visible portion and most important is the air temperature and solar radiation.

So, building interacts with all of them and some of them causes you know perturbation in the internal environment. So, building has to be designed such that it remains comfortable inside with the surrounding environment which might disturb the internal comfort. So, that is the interaction of the building with the environment in we can look into details of each one of this component, but in this short lecture I am not going to talk about that.

(Refer Slide Time: 03:42)



Because each of them, for example air temperature; now air temperature varies periodically over the year and diurnal variation is also there with which is also periodic. So, details of this and then their quantification, mathematical modeling in order to calculate the cooling or heating load that is possible. And, by doing from you know this aspects of air temperature, relative humidity etcetera etcetera which are the features of the environment, based on this we can define certain pattern of their variation which is nothing but climate. So, yearly variation that is what is climate.

So, therefore, if you see this India has been divided into 5 climatic zones as far as current you know national building code or ECBC that is energy code, you know energy conservation building code 2016 now; initially it came in 2007. So, related to thermal comfort inside the building are reducing the HVAC load energy efficient building.

So, you can see that there are 5 number of, there are 5 you know zones are there; 5 zones are there and this is called hot-dry desert; hot-dry desert, the red colored. This is composite monsoon climate, as you can see from here composite monsoon climate. This is cold largely Ladakh; part of Himachal, Uttaranchal and all that and some of the Arunachal Pradesh, some here also in Nilgiris and Western Ghats and then, temperate zone part of it is here. Warm humid climate largely in the Coastal areas and North Eastern area where there is high rainfall and so on.

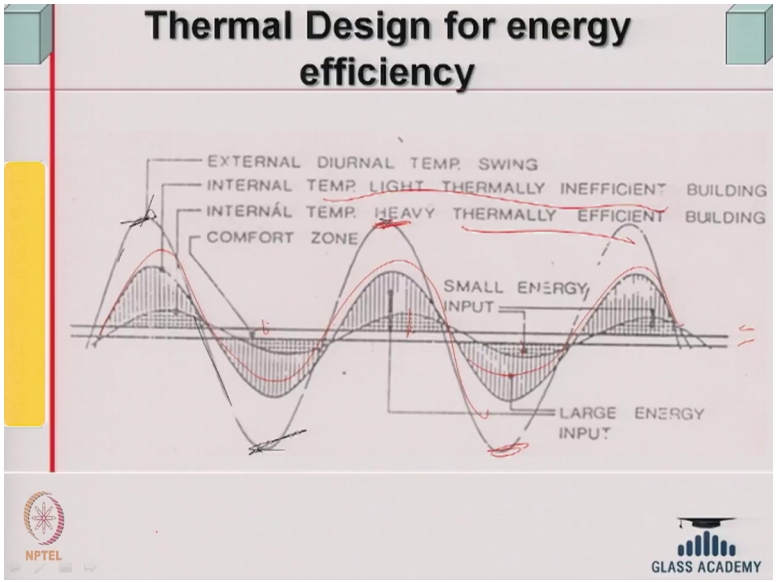
So, there are 5 climatic zones, the pattern of temperature variation, relative humidity, variation precipitation etcetera etcetera; there are some similarity in a given zone. They are more or less similar pattern is seen over the year and that is why I have divided them into such climatic zone. Now, performance is the building towards energy efficiency is related to this. For example, in a hot-dry desert climate, you know a hot-dry desert climate of this kind, you have large diurnal temperature variation; relative humidity is low; relative humidity is low in this zone and no precipitation.

Obviously, low vegetation; therefore, also in a dust storm is a part of this kind of characteristics of this kind of climatic zone. Therefore, the building should be designed in such a manner that you are you have thermal comfort inside the building under such kind of high diurnal variation and low humidity situation. While, if you come to this one which is called Warm Humid zone, you have high relative humidity variation; throughout the year, relative humidity is high and temperature variation is relatively low, daily maximum and minimum the difference is low.

So, under such kind of situation, the cooling load or thermal comfort they differ. Because thermal comfort is again a function of air temperature, relative humidity of the environment in which the human being is working and air velocity and what is called Radiation that comes from various walls or internal surfaces; it depends upon all those.

So, relative humidity and air temperature plays a major role and therefore, you know thermal comfort; nature of the comfort I mean whether you can have thermal comfort or not, here you have high temperature low humidity; here you have relatively slightly lesser temperature but high humidity. Both would be uncomfortable in some manner and they can be put in on some sort of indices which I have no discussing right now; but the climate is important issue.

(Refer Slide Time: 08:01)



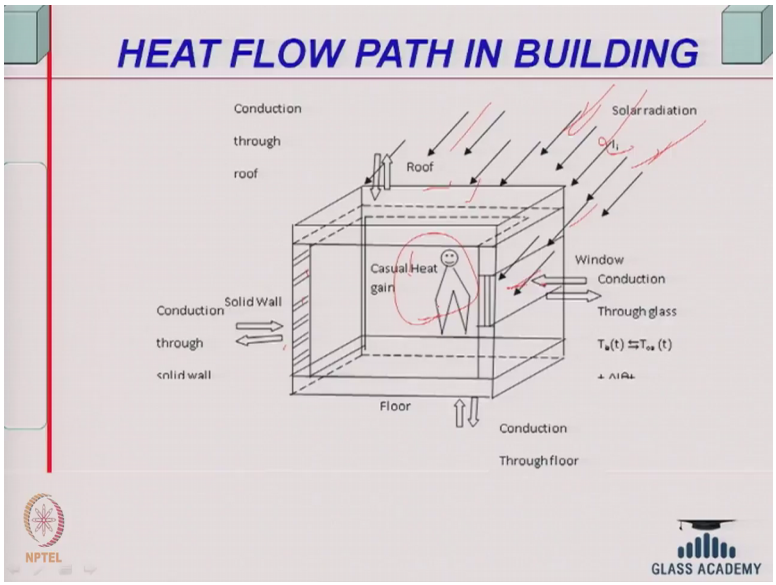
So, that is what first I wanted to point out. So, if I am trying to do thermal design for energy efficiency, this idea should be very clear. You know external daily variation that would be sort of a there is a maxima and the minima and you know maxima and the minima diurnal variation. Now, I can design my building in such a manner that using particular type of peripheral portion or envelope of the building and other make it internal temperature in light thermally efficient building or if I make it heavy thermally efficient building.

Then, this perturbation will get reduced so I can control this. This is what we call as comfort limit and comfort zone is somewhere there. So, I can design the building system so that I am very close to the comfort zone. But absolute control within that comfort zone putting it is almost impossible without mechanical or what we call without active system like HVAC and so on without air conditioner or you know heating and cooling system and so on.

So, thermal design is basically addresses this question. It tries to design finds you know we will talk about the factors which control which are the decision variable with reference to thermal design right. Decision variable for example, wall material and their thickness roof material and their thickness, the orientation shape etcetera glass; these are the decision variable and they have values or what type you should select that is the process of design.

And therefore, thermal design looks into this, my objective is to have a comfortable environment in a naturally conditioned building or my cooling or heating load or energy load should be minimal in a conditioned building or building with active system. Active system uses a lot of energy from outside passive system is part of the building itself.

(Refer Slide Time: 10:05)



So, if you look at that energy efficiency, then I got to look at heat flow paths in building, the solar radiation comes from outside. This is my building let us a schematic diagram right and solar radiation, if I have a glass; if I have a glass, then this solar radiation can enter into the space directly which might be good in winter condition; but direct radiation is not good in summer conditions.

So, we are able to see how we tackle them and there can be some conduction heat transfer, you know in solids heat transfer takes place by conduction. Solid heat transfer takes place by a phenomena what you call conduction and in fluid actually it is convection or movement of the molecules them self and radiation of course, does not require any medium. For example, from sun radiation comes straight away here.

So, this is my roof which will receive radiation and this radiation will heat up the roof itself and then, the heat goes inside and there can be conduction through the solid wall, there can be conduction through the roof. Radiation can fall onto the roof and then, by conduction goes inside and there will be air flow from outside to inside by design or by you know by design or by default some time because of infiltration because of leakages.

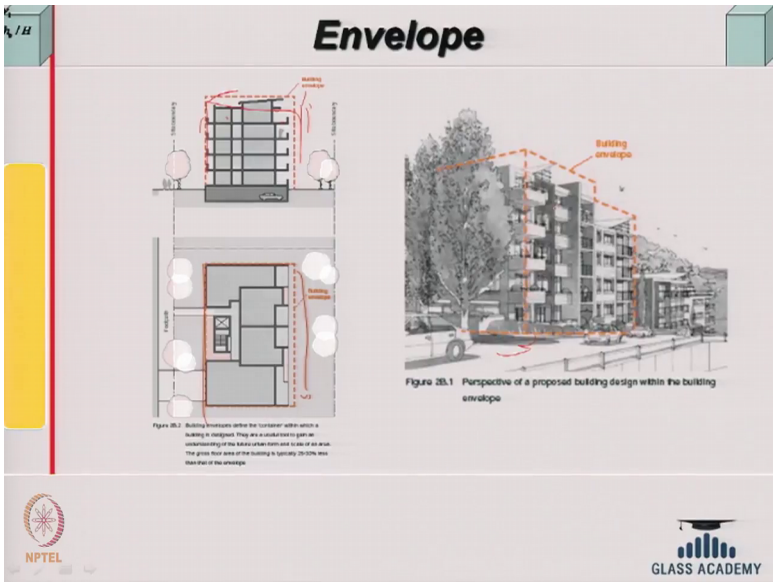
So, that would also cause movement, you know heat transfer and so mechanisms of heat transfer, if you look at it; conduction through the peripheral wall roof etcetera the elements in the periphery and ventilation heat transfer or air movement because of air movement that be some heat transfer. If outside there is warm, it will bring in heat; you know if outside warm air is warm compared to the inside air, it will bring in heat. If it is other way round inside the air is warmer, then the outside air during air exchange you know it will the cool air will come from outside to inside and so on.

So, this ventilation heat transfer we call it. Then, there can be casual heat gain because human being or appliances; human being also all the time whenever we are doing something including sleep sleeping, we our metabolic process we always generate heat because the food we take that you know is converted into some sort of energy; but all of it does not go into our body system development, cell division etcetera etcetera or in our work a part of it gives always is dissipated as heat right. The blood is always being circulated so part of it is dissipated as heat.

So, that is called metabolic heat. So, human being generates metabolic heat so this we call as casual heat gain. There may be many appliances such appliances also would generate heat. For example, if you were heater or some sort of thing you know even a fans which would actually heat up generate some heat, lights they will generate some heat. So, these are called all casual heat gain.

So, you can see Casual Heat gain, conduction through the solid portion of the opaque portion of the walls, direct radiation through the glasses and ventilation heat transfer these are the components of heat transfer and building. So, if I am looking at energy efficiency I got to look into this, you know and details of course, you can have some other courses.

(Refer Slide Time: 13:24)

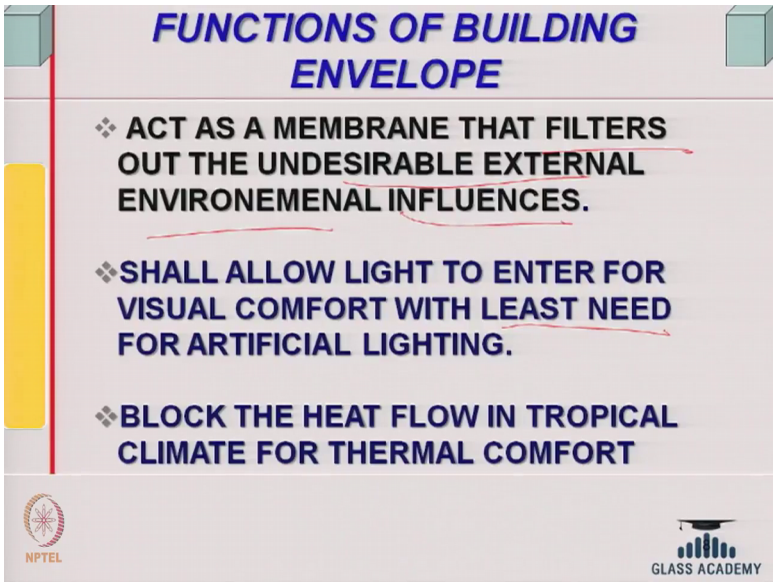


But here, we are looking into looking into you know quickly trying to introduce you to the thing. Now out of all this, envelope plays a major role; envelope, what is Envelope? A building envelope, if you see this is in plan, you know this is this is what is building envelope. This is my building there are some balconies sunshades etcetera etcetera.

So, the one just that covers that surface imaginary boundary you can say, it is a surface actually you know in all direction that is called Building Envelope; that is Building Envelope. And in plan, it will look something like this right. To make it more elaborate, this is what the building envelope would look like. You know envelope is that portion, you can say the skin, nearly the skin or just at the skin part of it, that is what we call as building envelope.

So, building envelope is one through which actually outside heat transfer takes from outside to inside. So, elements of Building Envelope are most important. They are very very important right they are important from energy efficient building design. So, this is your Envelope, this red line shows the envelope here this is the this boundary shows the envelop and so on; so this is what is Envelop right. So, they are very important.

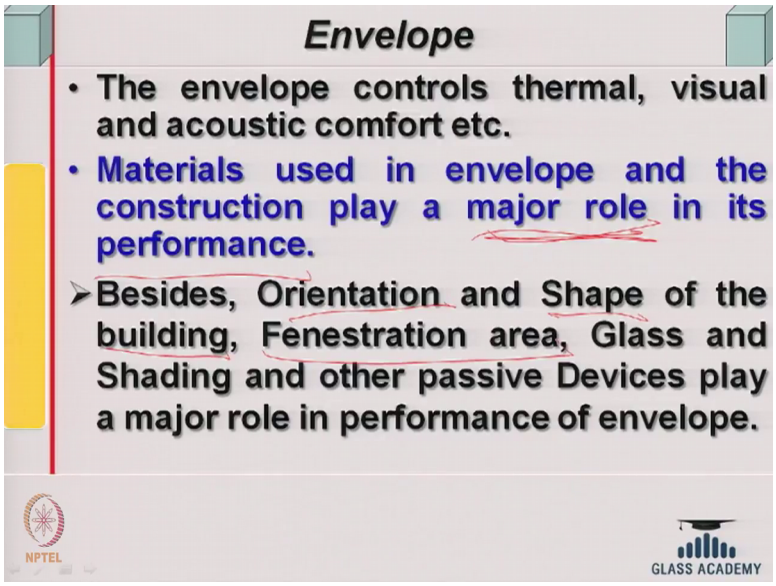
(Refer Slide Time: 14:37)



So, what is the function of Building Envelope? It acts as a membrane therefore, that filters out the undesirable external environmental influences right. So, for example, in summer condition I would not like heat to come in right, I would not like heat to come in. So, envelope must block it as much as possible, but I would like visible light to come in. So, it acts like a filter; allows light to come in, does not allow heat to come in. While in winter, I would like rather that heat also comes in along with light. Light can create another problem, direct light; for example, too much of light coming in, it can cause what is called glare, but light can reduce my artificial lighting load.

So, shall allow light to enter for visual comfort with lead least need for artificial lighting and then, block the heat flow in tropical climate for thermal comfort. The envelope also has a role to play in noise although that is not part of energy efficient building design. So, envelope should block external noise right. Envelope should block external noise and many other aspects of course, related to fire and all those functional design of building and this, this is of course, not a part of discussion.

(Refer Slide Time: 16:00)



So, envelope has that role also. So, the envelope controls thermal, visual and a couch acoustic comfort etcetera. Envelope also has some role because what is called built you know from the context of fire separation one building to another, the envelop has some role there as well and but, when for all in our context most important is thermal and visual comfort.

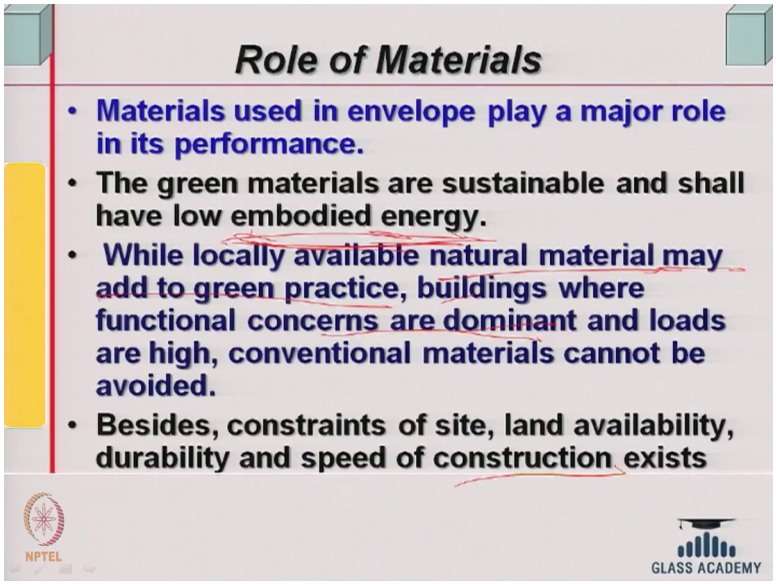
So, materials used in envelope and the construction play a major role. So, it plays a major role in its performance right. Materials in the envelope they play a major role in the performance of envelope itself and besides this envelope part, orientation shape of the building fenestration area. Now what is fenestration? Since, we are dealing with glass; you might have already come across this somewhere. You see fenestration is the opening left in the building envelope or facade deliberately for ventilation purpose in naturally conditioned building and day lighting, you know for light lighting purpose; as opposed to Infiltration. Infiltration is by default because there are leakages the construction quality is not proper, there are some leakages that would actually result in air to move in although light may not come in much. So, that is called Infiltration.

So, ventilation fenestration area is by design, fenestration area is by design and the type of glass you use that is has got an important role as we shall see because the glass should bring in the light, visible light diffused light as usual as we call it rather than direct sunlight. It should block the direct sunlight, but diffused light, it should bring in right the

heat part of the because as you shall see later on the suns radiation has got large component of heat infrared radiation as we call it.

So, visible portion of the light should come, the radiation should come and rest portion from the solar radiation should be block. And shading, we can devices we can use different types of shading and other some other passive devices, they play a major role in performance of energy efficiency in a performance of envelope in terms of energy efficiency.

(Refer Slide Time: 18:29)



Role of material is very important right. You must be familiar by this time that there is something called green materials and sustainable materials. Now, they shall have what is called low embodied energy, embodied energy. Now what is embodied energy? You see one thing is energy when you design for energy efficiency, energy that is coming from surrounding environment through the envelope into the building or going out heat energy going out that is part of energy efficient building design. But, if you are using a material which is actually consumed a lot of energy during production that is again, although it is one time; it is not good we would like to see that that is reduced. So, that part takes care of is taken care of in embodied energy.

So, embodied energy looks into the energy of production transportation etcetera, you know energy of production, transportation, construction during that phase whatever is a energy that is what you call as embodied energy. I have not go discuss do not discuss too

much unto this issue right. So, locally available natural material, they are green because they add to the green practice because you know they are locally available naturally available so you are just using them.

So, embodied energy they are very little. But buildings, modern buildings; for example, a hospital building large hospital building, academic institution building, offices, commercial building; now in such buildings you cannot produce with all naturally available building materials. Because the functional requirements, you know the functional concerns are dominant in such building; the load themselves could be quite high, depending upon type of occupancy as I said commercial occupancy, residential also some cases the load could be very high I mean I am talking with a gravity load or similar sort of load.

So, conventional material may not be, you know I mean engineered materials would be required there. So, you have to have manmade material rather than natural material. Other issues the durability- many of those natural materials they would be affected by the environment in certain manner. So, therefore, these issues becomes important and when you want to do a construction quite fast you have sight constraint, then you know speed of construction is there. In such cases, avoiding engineered materials becomes very difficult. So, you have to have you know engineered material, but you have to see that that engineered material is low embodied energy and it has got less implication means what is called operational energy.

(Refer Slide Time: 21:21)