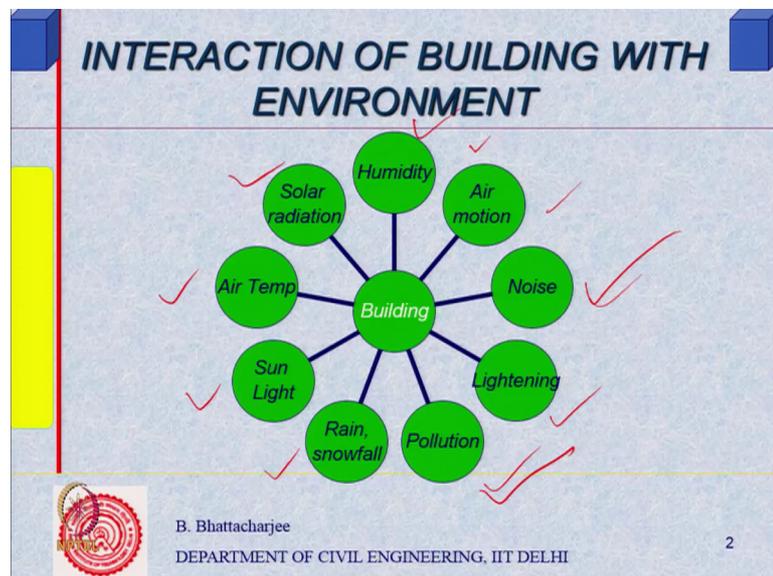


Fire Protection, Services and Maintenance Management of Building
Prof. B. Bhattacharjee
Department of Civil Engineering
Indian Institute of Technology, Delhi

Lecture – 35
Intelligent Building

So, having looked into you know some sort of introduction to various services right, introducing various services. We can now look into what is called an Intelligent Building right.

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So, if you recollect, I might have told you sometime, I am not sure whether told you in the beginning; that the building interacts with the surrounding and the external parameters of the environment around are something like humidity, external air motion, noise, lightening, pollution, rain, sun light, air temperature, solar radiation all you know relative humidity. Some of them we have already come across or you know, some will may not come across it does not matter.

So, this is how building interacts with it is environment, building interacts with the environment. These are the features of the environment. Some of them are manmade some of them are most of them are natural. This might be somewhat manmade this might be somewhat manmade right, but others are; so, others are natural.

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COMFORTABLE ENVIRONMENT

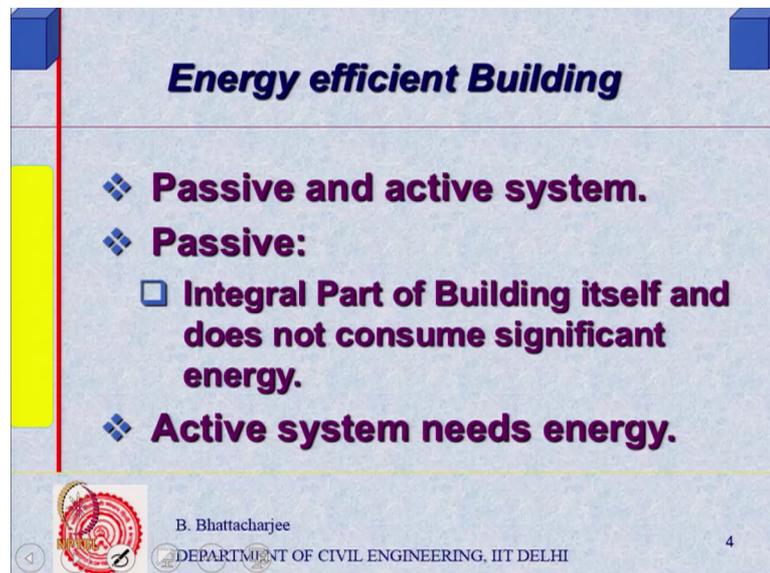
–Comfortable against external environment, both natural and man made;
–viz., temperature, RH, moisture ingress, condensation etc

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So, it must provide a safe environment against this comfortable against external environment both natural and manmade, that is what we have seen, temperature relative you know humidity moisture, condensation etcetera, etcetera against all of them it must be right.

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Energy efficient Building

- ❖ **Passive and active system.**
- ❖ **Passive:**
 - ☐ **Integral Part of Building itself and does not consume significant energy.**
- ❖ **Active system needs energy.**

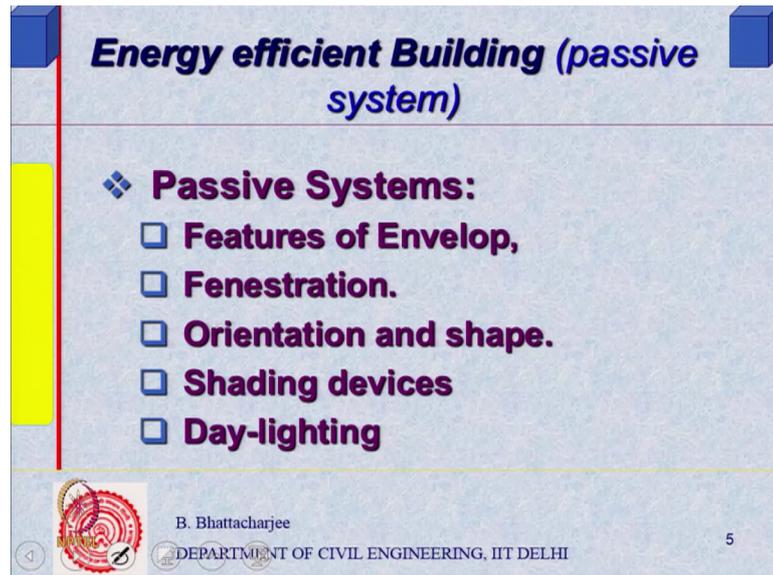
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And then we have seen there you can make energy efficient building, passive and active system. Passive means which are integral part both all kind of services, you might have some integral part of the building; which does not require any further energy you put it,

and does not consume sufficient energy. And active system would need additional energy. Like edge base we have talked about that will need additional energy. But supposing you are designing your envelope in such a manner that your q sensible that we talked about is minimal. You know the fabric heat gain is reduce down when that would be through passive means. So, that is what it is.

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Energy efficient Building (passive system)

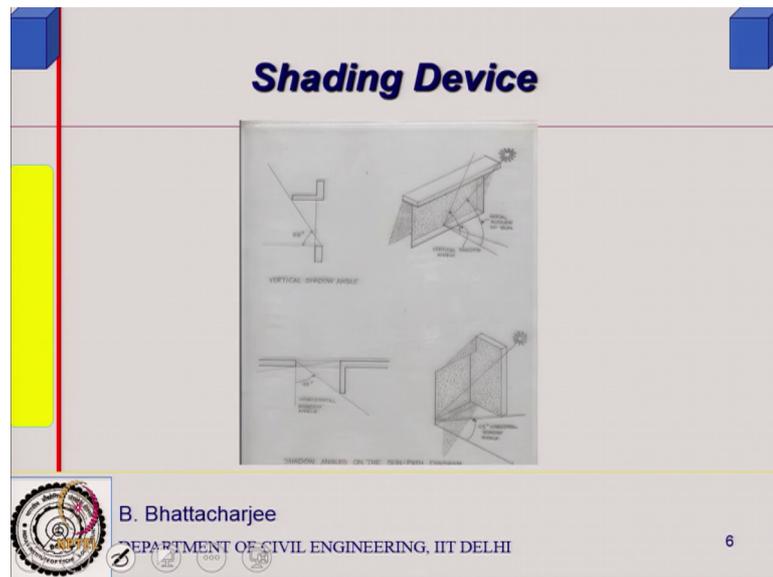
- ❖ **Passive Systems:**
 - ☐ **Features of Envelop,**
 - ☐ **Fenestration.**
 - ☐ **Orientation and shape.**
 - ☐ **Shading devices**
 - ☐ **Day-lighting**

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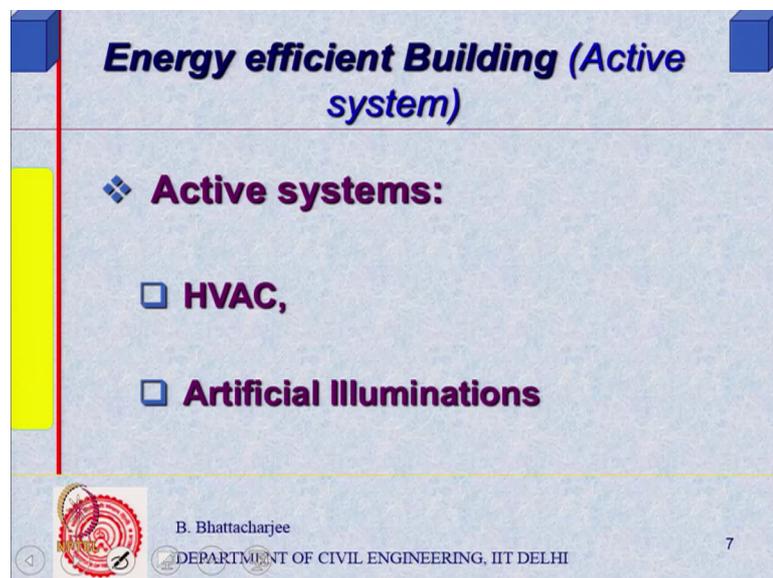
So, we have seen you know this can have different like envelope, fenestration, orientation, shape, shading devices delighting we will not discuss them here. But I am just telling you this was the part of the passive system right.

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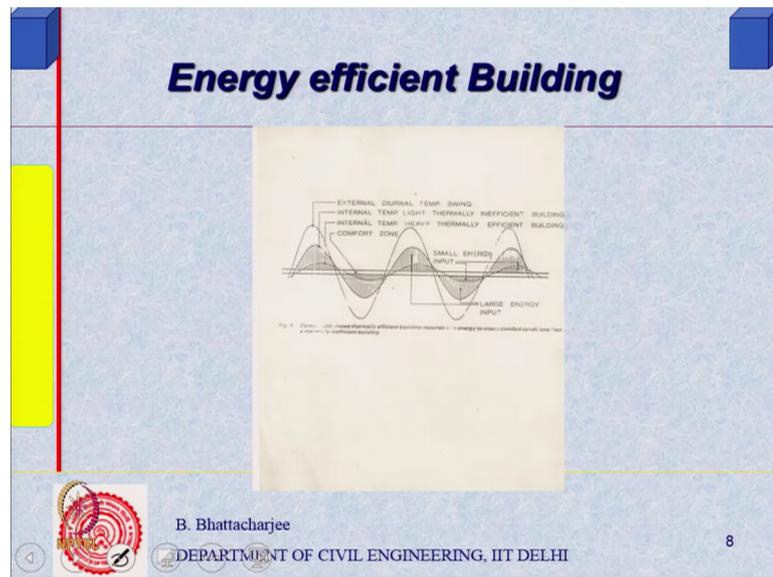
These are shading devices which I will not talk about these are the example of shading devices and you cut down in the sun, you can design such system.

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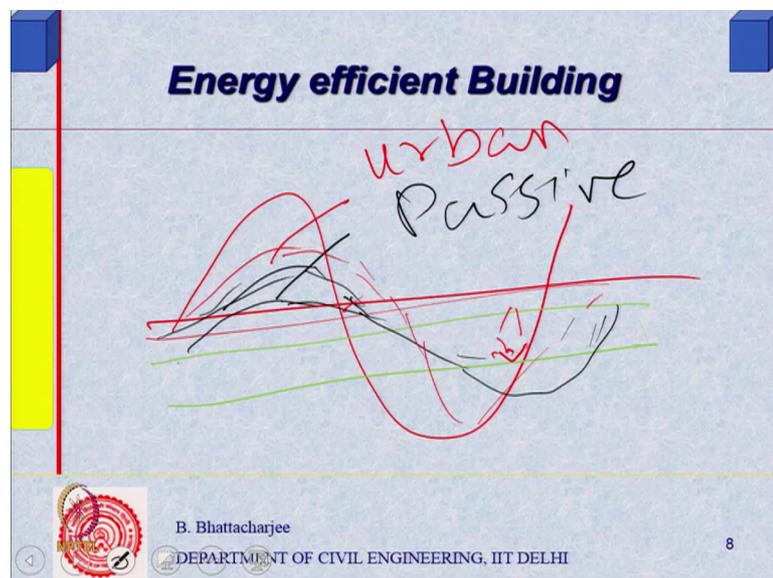
Active system I am just giving an example of passive system. Active systems are HVAC which we talked about. Heating ventilation you know artificial illumination, lighting, these are somewhat active system.

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So, basically if you look at it, you can control some of the you know, just let me draw it first of all natural variations could be something like this.

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Let me take you can take diagonal variation daily variation of temperature. So, natural fluctuations or humidity they fluctuate, they changes. And your comfort condition is somewhere you know they fluctuate somewhere your comfort condition might be somewhere, your comfort condition might be; somewhere there, something like this in between right.

And your comfort condition might be somewhat this one. So, what you can do is, by doing passive design, by doing passive design, by doing proper passive design you can bring down this perturbation. Might change their phase and all that, might bring down this perturbation somewhat. So, that you are close to your comfort zone somewhat.

The green one is a comfort range what you desire right, comfort zone as you desire, this might vary. So, by using passive means by passive means can; that means, even before passive by urban design provide, the providing plantations you can do what is called microclimatic changes right.

So, plantations of planning it properly air movement is controlled and so on. So, lighting is you know adequate in every houses, and recovery figures mutual shading from one building to other etcetera etcetera. So, first is urban planning can reduce it down, urban planning stages can reduce down somewhat, urban planning stage can give you somewhat better scenario, somewhat some perturbation reduce reduction is possible.

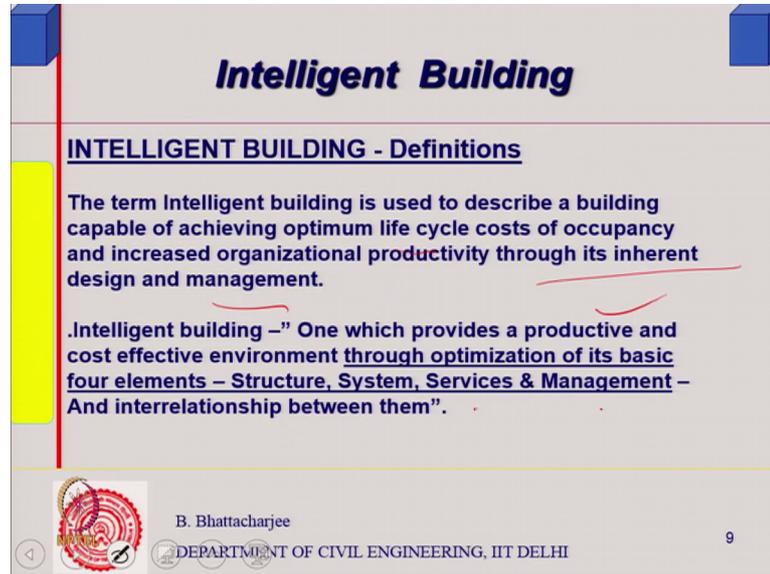
Then you come to the passive so, urban planning, urban planning then passive, but beyond that you have to use active. Beyond the limit you cannot passive cannot bring it to this range. So, you have to use active so, active system means energy input would be required HBSE artificial lighting, etcetera, etcetera and you would like to minimise those that is number one. But then you see, it is better, you if you keep it at constant value or active system operates at a constant level all the time, then sometime it you know it will not without looking at the requirement within the space.

Without looking at the requirement within the space, then many a time it will be wasted. For example, supposing the room is not occupied, but air conditioner is running, because you have device it in such a manner; like we talked of control system, somebody comes and put on in the central AC at 8 AM, because the office starts at 9 AM, but all the spaces in the office is not really occupied all the time.

So, in that case there be wastage of energy, even if you have an active system, we will bring down the end within the control, but there will be wastage of energy and possibly over do the whole thing. Now if you put control that we have said we talked about then; obviously, it can make it within that operating differential very easily. So, therefore, control means when we talked of control we said that we need a feedback. And when your feedback when your feedback when your feedback so, this diagram shows the same

thing what I talked about urban design and then you know like passive. And then you want within the that narrowband of comfort zone have to use the active system.

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Intelligent Building

INTELLIGENT BUILDING - Definitions

The term Intelligent building is used to describe a building capable of achieving optimum life cycle costs of occupancy and increased organizational productivity through its inherent design and management.

Intelligent building –” One which provides a productive and cost effective environment through optimization of its basic four elements – Structure, System, Services & Management – And interrelationship between them”.

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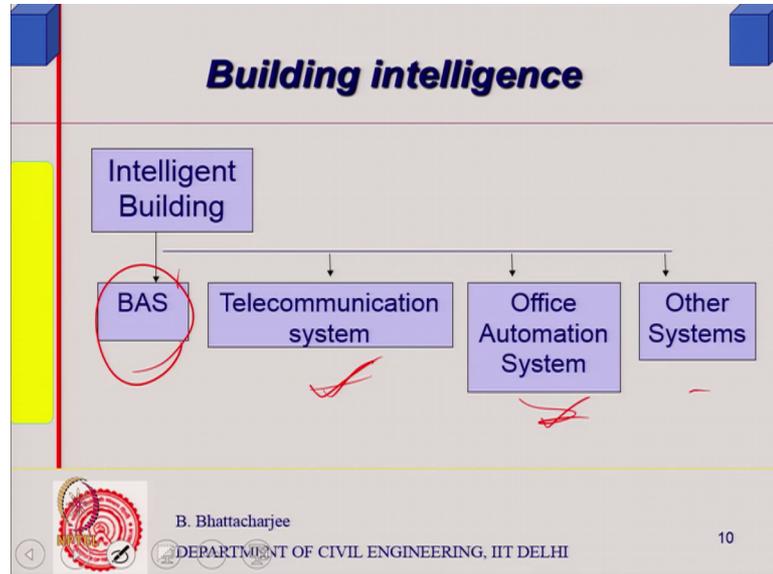
And when your all control system are controlled through computer, then it gives you know it becomes an intelligent building. In an intelligent building, the control systems will be there in many features, right. Control system would be there in many features, and control system means you will have a feedback.

So, you will have sensors, this sensors will sense the condition within the control environment, sends signal and when all the full number of them are controlled together with a computer that becomes an intelligent system. So, definition is something like this. Intelligent building is used to describe a building capable of achieving optimum life cycle cost of occupancy and increased organisational productivity so, it is inherent design and management.

Well, this is very broad definition; because over all life cycle cost it will improve, it will optimise the life cycle cost and of occupancy and increased organisational productivity also because it will maintain the ideal condition all the time as required right. So, essentially one which provides productive and cost effective environment through optimisation of it is basic 4 elements. Structure system, services and management, and interrelationship between them, interrelationship between them; so, this is what the

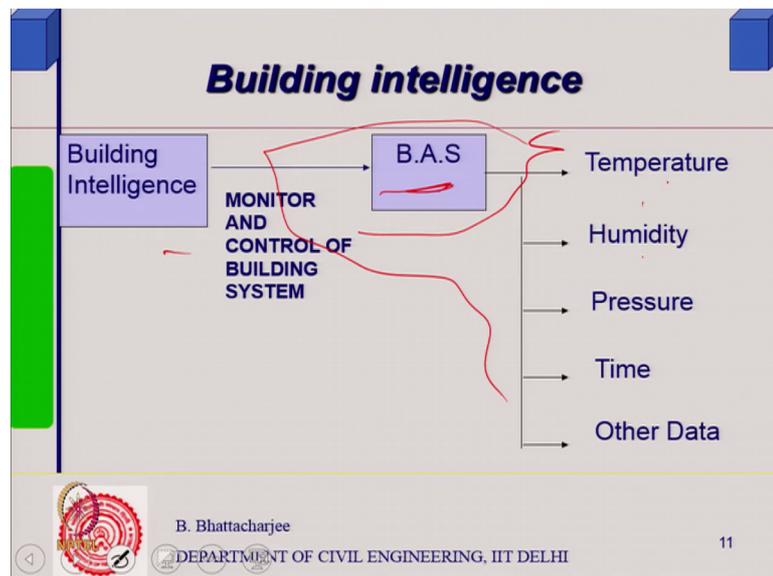
definition of intelligent building is. So, that you know this building intelligence is essentially based on something like this.

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So, this is what is you know we will have what is office automation system telecommunication and all-inclusive right.

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All inclusive, let me see will come back to this later on a little bit first diagram again. Temperature, humidity, pressure, time, other data; so, there is a for building active systems temperature data these are all connected. And this is an integral part, you know,

this is an integral part of an intelligent building. So, this will monitor and control, you know, merging monitor all the data right.

So, building automation system will monitor all the data actually temperature humidity pressure time, or whatever you desire, and then that builds in building, you know, intelligent system. So, therefore, if I look at it in edge, this will be this is the data acquisition then telecommunication and system; office automation system and other systems all systems are automated. All systems are automated and that results in intelligent building so, that is what is it.

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Control systems in Building

BUILDING CONTROL SYSTEMS

- Automatic Controls are used where variable conditions must be controlled.
- Control System should be integrated with system design both have to work in harmony after final installation.
- Majority of Control are for HVAC System.

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Automatic controls are used where variables condition might be controlled. So, you have automatic that is all right thing. Control system should be integrated system design, both have to work in harmony after final install final installation. Majority of controller for HVAC system; majority of the control, but then you know like many places, nowadays is very easy thing you enter then you find lights becomes on.

So, essentially similarly you know HVAC system temperature is monitored, now if there are lot of people; obviously, the heat to be removed; is more if there are no people if without doing much you can monitor possibility. But also although if also if it is equipped with another system where it looks into the presence of human being, the signal goes in there is a man person enters or person goes out. Then you know you can go to any extent actually. It is you can go to any extent even go to any extent right.

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Control systems in Building

OBJECTIVES OF CONTROL SYSTEM

- Safe plant operation ✓
- Protection to the building and system components. ✓
- Maintenance of desired conditions. ✓
- Economy in operation ✓

WHAT DOES IT DO

- Limiting plant operation period ✓
- Economical control of space conditions ✓
- Efficient plant operation to match the load ✓
- Monitoring system performance. ✓

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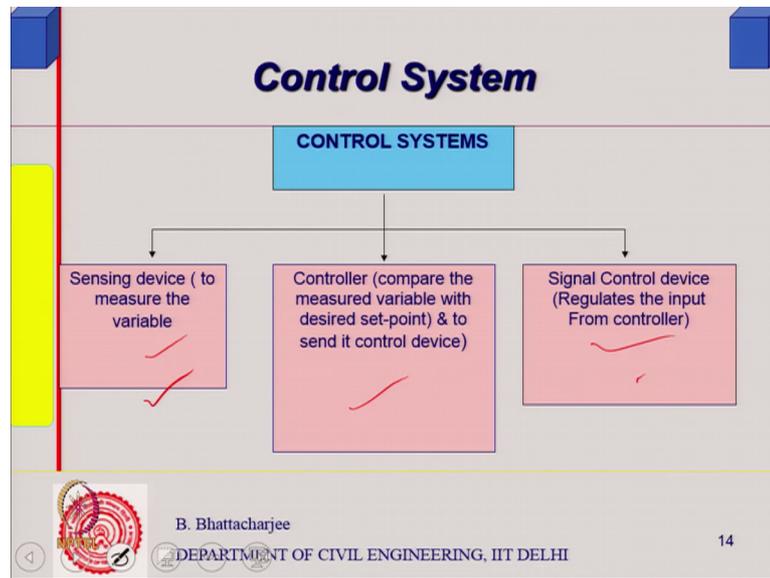
So, objective of control system are safe plant operation; protection to the building and system component completely maintenance of desired condition and economy of operation. Now, you see in earthquake structural system also, you have active control system, against earthquake, there are various kind of you know like it is a domain structural engineering, research domain of structural engineering. And there are various kind of active control system; where during the earthquake, the building react in a given manner to counteract the effect of earthquake on to the structural system.

So, all put together, the complete intelligent building system will have everything possible. But then in services of course, this is been used earlier than fire for example, automatic sprinkler system automatic. Sprinkler system is nothing, but an intelligent system. The moment it sees so, this is been there for quite sometime. And that is why the safe operation protection of the building and system components, maintenance of maintenance of desired condition, and economy final it results in, because you will use it only and only when it is required. Limiting the plant operation period therefore, it does limiting the plant operation period.

Economical control of the space condition; it will not go too far beyond right, and efficient plant operation to match the load monitor the system performance. For example, if I had you know you remember we talked of in case of water supply system or general system we talk of; we need storages. Because there is a imbalance between demand and

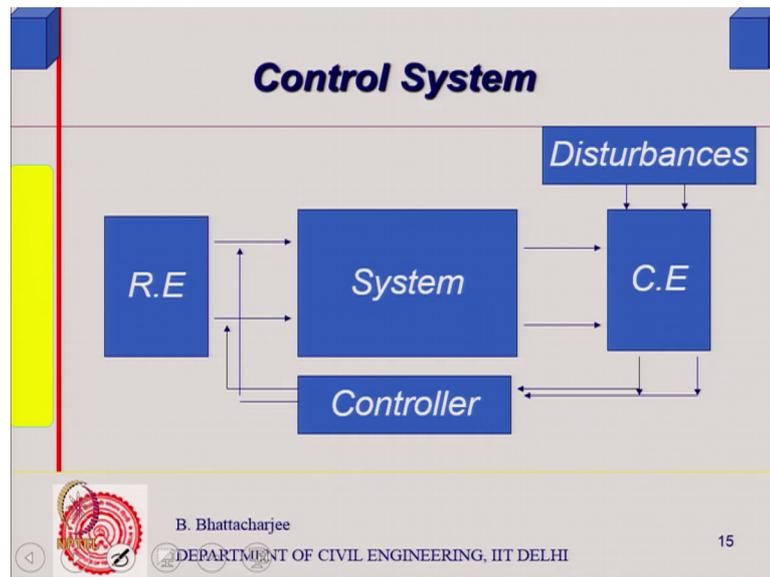
supply. Supposing I can control my supply in such a manner that match exactly the demand, when I would need unit storage; so, if the better control on my supply would actually minimise the storage cost and on. So, that which that is the idea, that is the idea.

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So, control systems will have sensing devices. It measures the to measure the variable values of the design variable which we talked about earlier. Controller they compare the measured variable with the desired set point, that we have already talked. You know, and to send it to control device signal, control devices regulate the input to the controller. For example proportional valve opening etcetera, etcetera that is what it does the control system does.

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So, disturbances this we talked about earlier and this is where it is, you know. So, this is this is when you do it for almost all variable to a single system, automated system that gives an automatic, you know intelligent building actually.

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The slide is titled "Control System" and has a sub-heading "WHY CONTROL SYSTEM IS NEEDED". The text explains that the nature of heating and air conditioning systems is such that for the majority of the period of operation, plant and system capacity will exceed demand, and the order of this excess varies with time. It states that steady state conditions may never occur, and if the plant were uncontrolled, conditions in the occupied space would be outside the desired range, making control a fundamental requirement. The slide includes a footer with the name B. Bhattacharjee, the Department of Civil Engineering, IIT Delhi, and the slide number 16.

Well, nature of heating and air conditioning system is such that for majority of the period of operation plant and system capacity will exceed demand, right. You will if you put it on for all the time, and the order of this excess varies with time. How much, you know, what is required and how much you are actually providing. Usually you provide more.

Steady state condition maybe assumed which is; obviously, never occurs that is the assumption will make actually there is a variable state for the load required, variable states, you know is time variant. Then if the plant where to be uncontrolled, the condition of the occupied space should be outside the desired range, and consequences of which some means of control is fundamental requirement. So, that is what we have seen earlier also.

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The slide is titled "Control Methods" in a bold, italicized font. Below the title, the text "CONTROL METHODS" is written in a bold, blue font. Underneath, the word "CONTROLS" is followed by a list of control types: "- Analogue Control", "Analogue Input", "Analogue Output", "- Digital Control", "Digital Input", and "Digital Output". The slide features a yellow vertical bar on the left side and a red vertical line. At the bottom, there is a logo of IIT Delhi, the name "B. Bhattacharjee", and the text "DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI". The number "17" is in the bottom right corner.

And various types of controls are analogue, analogue output, digital control, digital input and digital output. Now, essentially um, you know, these are the system that is available, but today everything is now digital system.

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Control Modes

CONTROL MODES

- Two position control
- Proportional control (P)
- Integral control (I)
- Derivative control (D)
- Adaptive control (A)
- Floating control
- Step Control

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And 2-point control I have already talked about; proportional control, integral control, I have mentioned. Derivative control, adaptive control, floating control and step control these are the other types. So, we have discussed about some of the features of this ones earlier, and there are some more available.

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Control Methods

CONTROL SYSTEM TYPE

A) Pneumatic – (Not common now)
B) Electric / Electronic

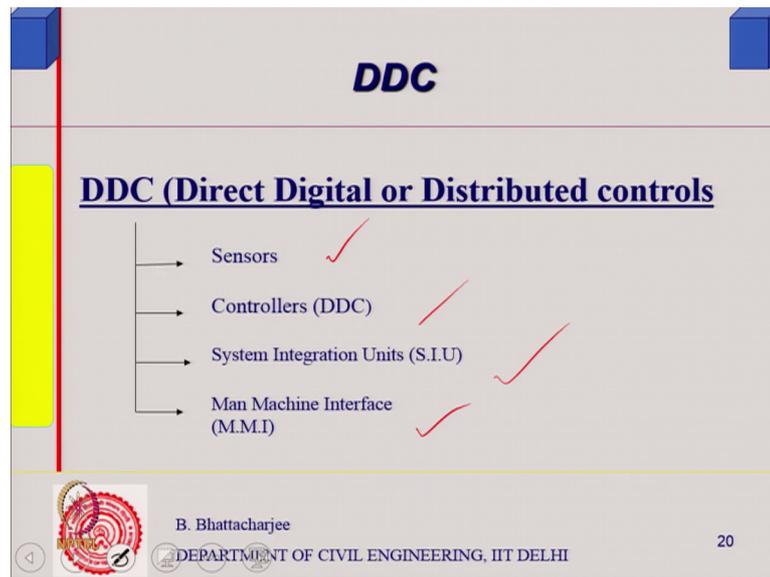
DDC (Direct Digital Control)

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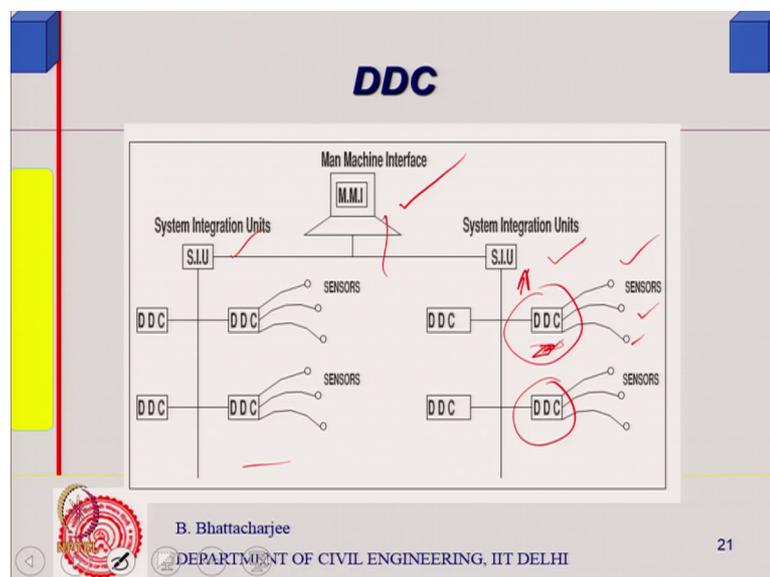
And methods is pneumatic not common, today it is all direct digital control. You know, electric or electronic and today, it is all direct digital controls. So, that is what it is DDC that is what it direct digital control so, that is what they have.

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And they will have sensor, controllers system integration units, and man machine interface right. Which could be simply the you know like monitors and things like that so, that is man machine interface.

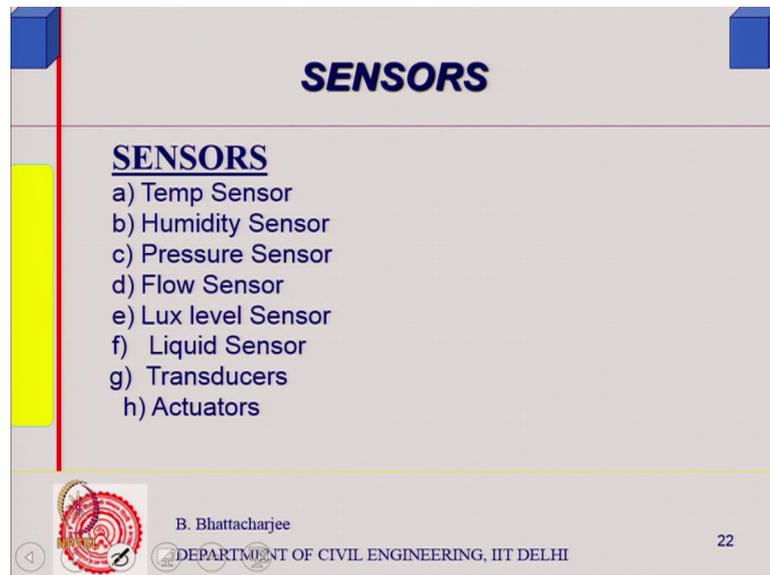
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So, that is what it is you know so, man machine interface, that shows it, then system integration, unit system integration units the DD, you know. Direct digital controls, there are centres, sensors from where the like there may be space where you have from where you direct digital controls come DDC, DDC their system integration units, and they are

finally going to man machine interface. So, this is what this schematically for an intelligent building. This is what, you know, it looks the controlling system looks, you know, schematically looks like this ok.

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The slide features a title 'SENSORS' at the top center. Below it, a list of sensor types and actuators is provided. The slide also includes a footer with the presenter's name, department, and slide number.

SENSORS

SENSORS

- a) Temp Sensor
- b) Humidity Sensor
- c) Pressure Sensor
- d) Flow Sensor
- e) Lux level Sensor
- f) Liquid Sensor
- g) Transducers
- h) Actuators

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Sensors could be for temperature, humidity, flow, lux level, pressure, liquid sensors, you know, height of the tank right. Various other kind of transducer and actuators, the actuators are required if you want to counter something. For example, in earthquake they use you know actuators or somewhere which will induce vibrations things like that could be various kind of things.

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DDC

Each DDC controller identified by no. of points (Connection with no. of sensors) it is connected to comes in modules of 4, 8, 16, 32, 64, 128. More the no. of DDC means each DDC connected to lesser no. of points – Cost goes higher if more controllers are there.

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Each DDC, controller identified by number of points connection with number of sensors. So, every direct digital control system will have number of sensors. Sensors are identified by number centre; it is connected to say module in modules of 4, 8, 16, 32, 64, 128 etcetera, etcetera in a in terms of this. So, more number of DDCs means each DDC connected to lesser number of points.

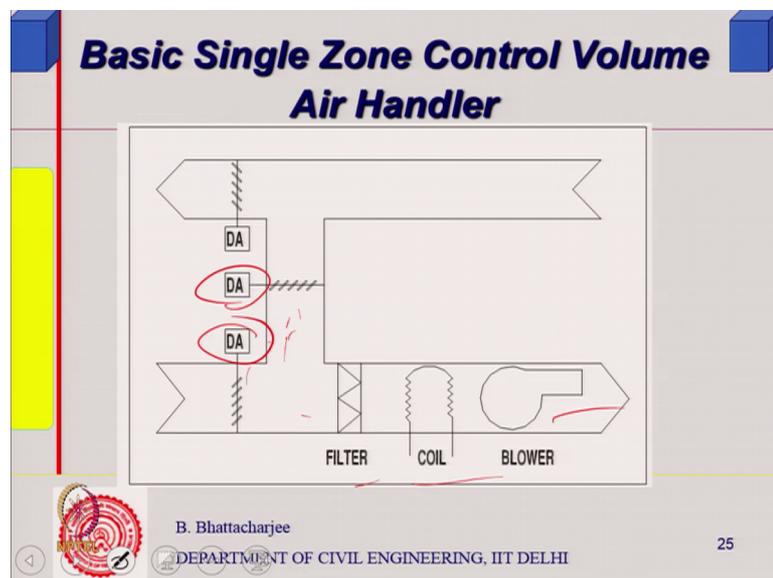
If you have more DDCs less number of sensors will be connected to it. Cost goes higher if mode controller are there. If DDC controllers are there so, you have to actual optimises or other. You have to see that is optimised, because it is a electronics or you know, the hardware engineers will do this kind of job. But we have the knowledge that this is to be optimised. More DDCs more cost; less DDCs, you know, less DDCs the system optimisation system performance might be effected and so on. And this is what typically it might look into.

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Some cases man machine interfaces, DDC controllers, this might look into some places, there is actual photograph of a building.

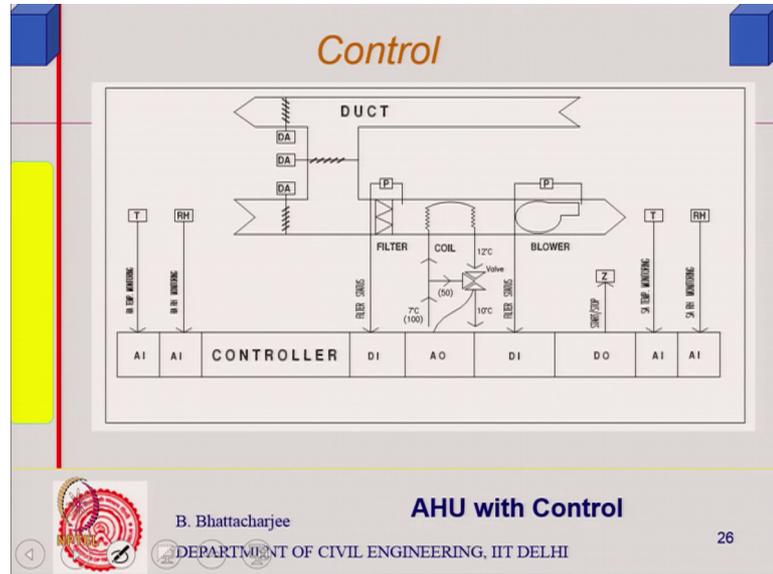
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And a basic case single zone control you know for example, in air handler. For example in an air handler so, this was our blower filter etcetera, etcetera you see. Now the control would be, you know, the this the finally, the amount of flow, that is to be controlled. So, you will have DDC of course, not shown here. So, for example, the quantity of flow finally, has to be you know so, these are the direct active control, direct active control,

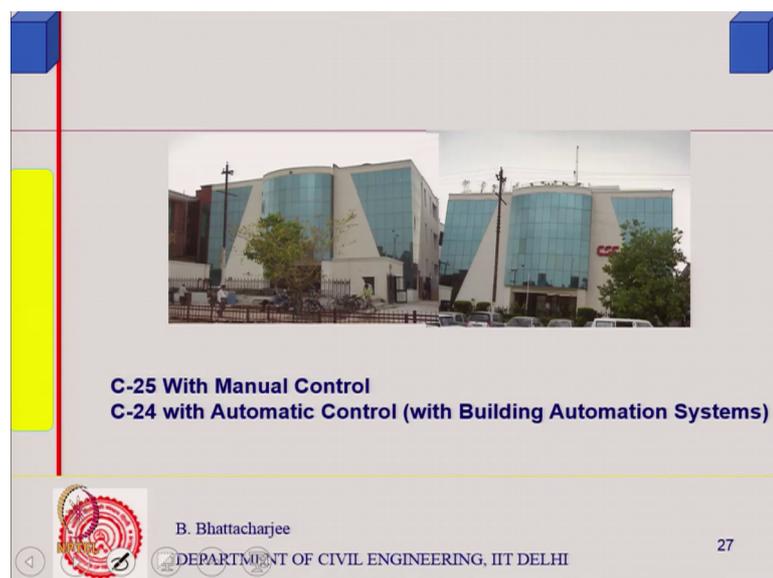
they would control the amount of flow and DDCs actually send the signal and actual controller will control right.

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So, the details something like this; the controllers are here; this is your air conditioning system. The duct in the controller sensor signal and their flow will be controlled. So, this gives some schematic of; you know, some schematic with the air conditioning system how controller can work, ok.

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These are 2 buildings, one with a manual control; this is with the automatic control. I think this is somewhere in Gurgaon. One of my student gives a project and we are trying to compare how do they perform, 2 buildings, almost similar one with the manual control another with automatic control with building automation system. Somebody has to monitor them. So, you know they are they are of course, still there are some as I said this was supposed to be partially intelligent the India habitat centre, the computer maintenance CMC building in Mumbai and all that. So, the report of the performance is we are not really known, but somewhere some as to look into, what is the cost saving and of course, the performance related to the people know what do they feel about it.

Because, their comfort condition if it is maintained adequately or not; CBRI I has got a building constructed, instrumented with various kind of system, building means is a it is just about a two story height building, small buildings. And they are possibly the some experiments they will be doing so much not much data is available at the moment. On Indian side, how do they perform, but they actually these are the system one calculates. So, this is the ultimate of service system with total control system, right. So, that is it that is about intelligent building.