Sustainable Architecture
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Lecture – 42
Indoor Environmental Quality - II

Good morning. Welcome back to the second lecture in this week where we are discussing about Indoor Environment Quality as part of the online ongoing course on Sustainable Architecture. So, in yesterdays lecture; we discussed about the different terminologies which are of relevance when we are discussing about indoor environment quality. We looked at the thresholds, the limits of different compounds we looked at the different types of pollutants and their sources.

And we also looked at, what are the different responsible components within the building whether they be system or design which are relevant when we are talking about the contamination or indoor environment quality. Today, we will be looking at some of those strategies as to how can we improve upon the indoor environment quality.

So, we will be largely looking at the air quality as part of environment quality in this lecture. Other relevant parts of indoor environment quality. For example, day lighting and others they will be taken in subsequent lectures. So, when we talk about indoor air quality; the first and the most important property or process which is to be discussed is ventilation. Now, ventilation as we have seen may be natural ventilation or mechanical ventilation.

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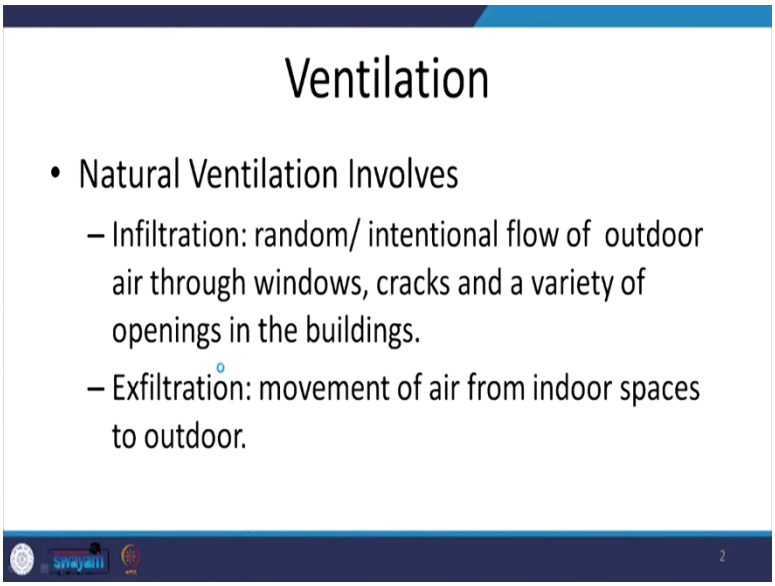

So, when we are talking about ventilation; in this we may be providing natural ventilation and natural ventilation would involve infiltration which is bringing in of air unintentionally through windows or cracks in the openings of the buildings. So, that is the infiltration and there is exfiltration which is movement of air from indoor spaces to outdoor spaces. When we are looking at providing adequate natural ventilation; we have to know the limitations of natural ventilation.

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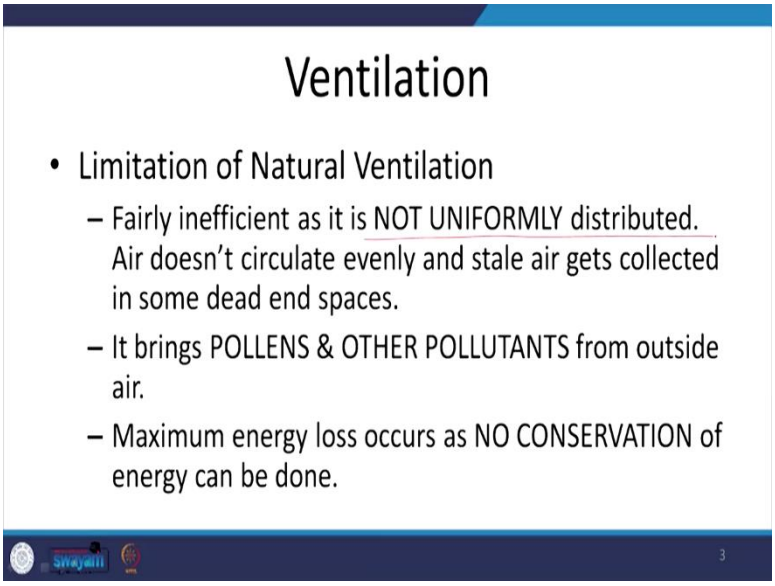

First of all it is often not uniformly distributed through the building because, there may be a force of air because by virtue of the design which may create eddies or which may not create the wind current, the air movement in certain pockets of the building.

So, wherever the air does not circulate evenly the stale air gets collected and there are some dead spaces dead end spaces which are created because of natural ventilation. Another thing is, natural ventilation brings along with it the pollens and pollutants from the outside air. Because, there is no control on the quality of air which is being brought in we may design for the quantity of air which needs to be brought in, there is no control on the quality of air.

And, because of the temperature of the outside air which is not controlled there might be energy loss or gain. So, basically energy exchange which might occur because there is no conservation of energy which can be done in through natural ventilation. The other type of ventilation which we have discussed is mechanical ventilation. Now it involves the use of mechanical equipment which are fans heating or air conditioning equipment, pumps and all of these are motor driven.

So, the basic principle of mechanical ventilation is to bring in the fresh air from outside, outdoors to indoors spaces and exhaust the used, consumed stale air which is their indoors to the outdoors and along with that controlling the quality of air in terms of wests temperature and humidity its contaminants its particulate matter.

So, all of that is part of mechanical ventilation. So, when we are talking about the compliance from green building perspective. There are minimum requirements. So, it is specified through ASHRAE standard 62.1 2007 which is for ventilate of acceptable indoor air quality or there are several local standards also. So, for India, we have different standards or we may be following ASHRAE standard 62.1.

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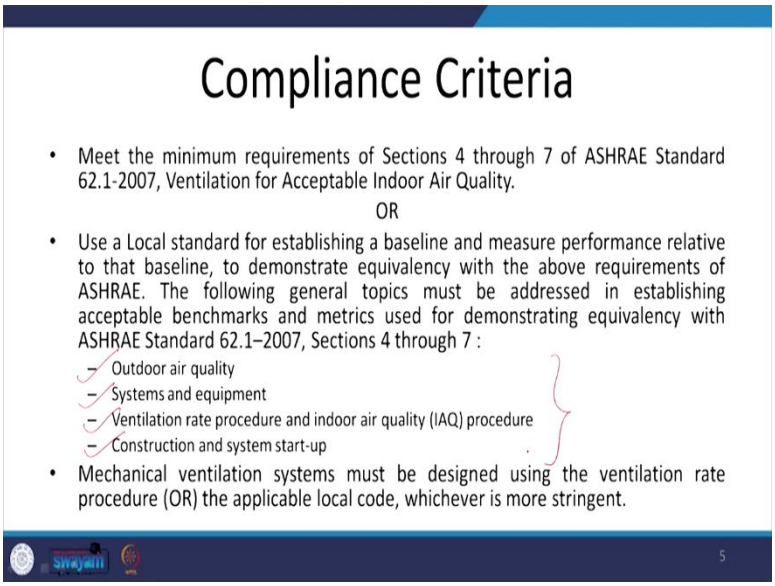

But either of these, they will be talking about mainly four particular sections, properties; one which is the outdoor air quality which is being supplied. Second is systems and equipment. Next is ventilator ventilation rate procedure and indoor air quality procedure and then lastly construction and system startup.

Now, when we are talking about all these four; we are talking about design of mechanical ventilation systems as per the applicable code whichever is more stringent. So, it could be ASHRAE or it could also be the applicable local code whichever is more stringent, but all these four will be taken into account.

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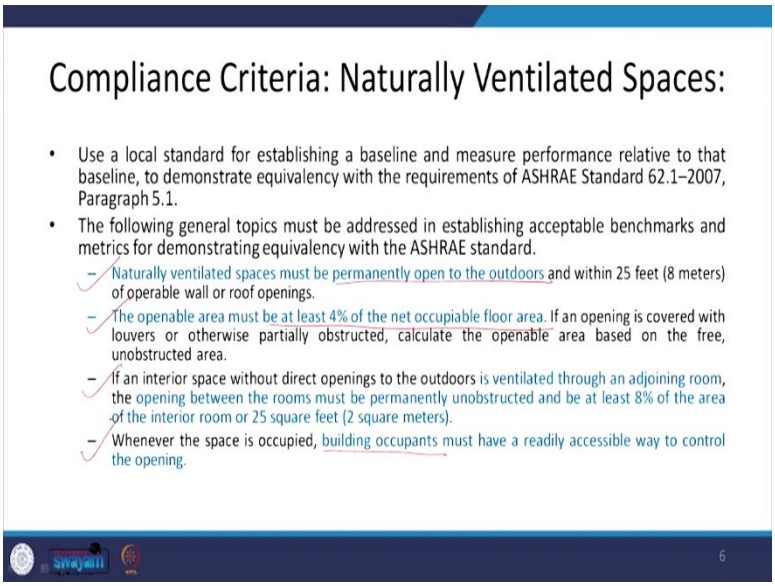

So, largely when we are talking about these, we are talking about the rate of ventilation and also the quality of air as far as the thresholds of contaminants is concerned. So, in general, when we are talking about complying with the criteria given as per ASHRAE standard 62.1. We talk about naturally ventilated spaces which must be permanently open to the outdoors.

We talked about the openable area which must be at least 4 percent of the net occupied floor area. We talked about the opening of fenestration openings to the outdoors which are ventilated through an adjoining room. So, it may not be directly opening onto the outside, but it may be ventilating through an adjoining area which is opening to the outdoors.

And then we talked about the control which is given to building occupants in order to control their immediate environment by allowing them to control the opening or to change the temperature, humidity and all these things. Now in case of naturally ventilated building it will only be the access to control the opening. So, when we are talking about the air ventilation rate we are talking about the supply rates.

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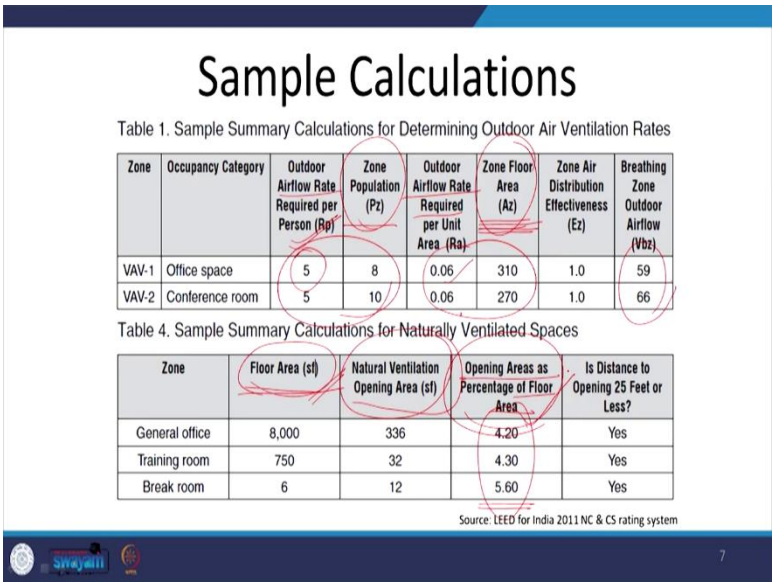

So, for naturally ventilated cases or the mechanically ventilated cases, two things which are important for designing the rate at which air will be drawn or ventilated is; first of all it is the floor area. So, we have to look at the floor area, how much area has to be ventilated.

And the second is the population. So, if there are more people in an area. If the density is more, both of these have to be considered. So, for any space both of these will be considered as per the standards; the rate of air flow per person is already specified. So, per person a rate of air supply is specified as per the code which has to be ensured also for per floor area basis the outdoor air flow rate is specified.

The final air flow which is required for which the system will be designed in case it is mechanical system is an addition of both the requirements for per person as well as for the floor area. And the total air flow rate which will be required is on the basis of this calculation which is for the population and area.

In case, we are going for natural ventilation in that case; per floor area the amount of opening which is provided as a percentage to the floor area will be determined and this is what is specified in codes. So, if is naturally ventilated, then the percentage of fenestration opening areas as a percentage of floor area is specified and that has to be achieved and met, if we look at Indian codes even the location of the opening the height, the angle at which the incident air, the dominant wind direction all of that will also count towards the air change rate.

So, sometimes, we look at the air changes per hour which is there as a benchmark for the naturally ventilated space and it is also available in most of these standards. So, not just the opening area as percentage of the floor area, but we will also calculate the air changes per hour depending upon the opening areas as percentage of floor area, the orientation of openings with respect to the wind direction, the design of openings with respect to other openings and the circulation of air which is carried out in the space.

So, all this will be the part of compliance approach when we are complying, when we are following the standards for green buildings. So, this was for ventilation.

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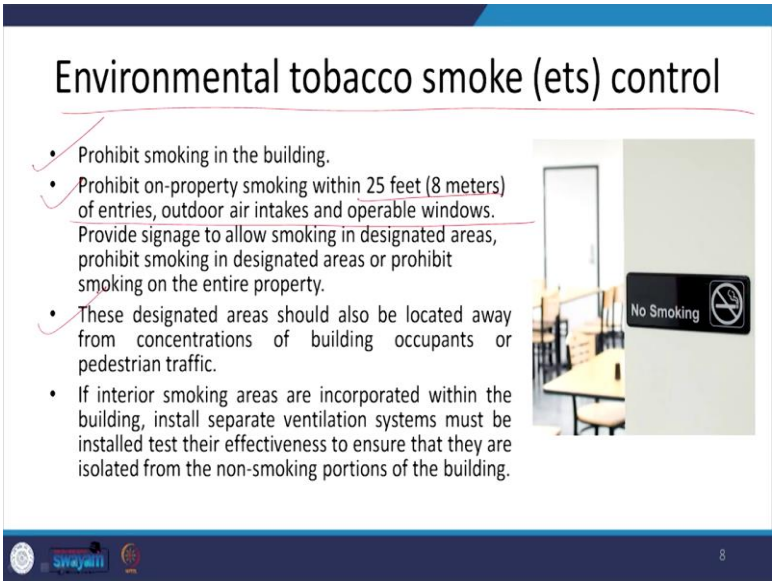

The next, we have for environmental tobacco smoke control. As I was discussing in the previous lecture of yesterday; the intent of environmental tobacco smoke control is to isolate the tobacco smoke and not let other occupants who are non smokers get exposed to this environmental tobacco smoke.

So, the various steps in which we can do that is; first of all prohibit smoking inside the building, if that is possible. In case, it is not possible or besides this we also prohibited prohibit smoking on the property within 25 feet of entries and outdoor air intakes and operable windows. So, even outside the building also within the property on the property smoking should be prohibited. In case prohibition is not working or in addition to that as well we might, we should provide designated areas for smoking they should also be located away from concentration of building occupants or pedestrian traffic.

So, it should not be where mostly the building occupants are. So, there should be a designated area and slightly away. And in case, there is an interior smoking area which is provided then it has to have a separate ventilation system it cannot be managed with the same air ventilation system which is supplying to the rest of the building.

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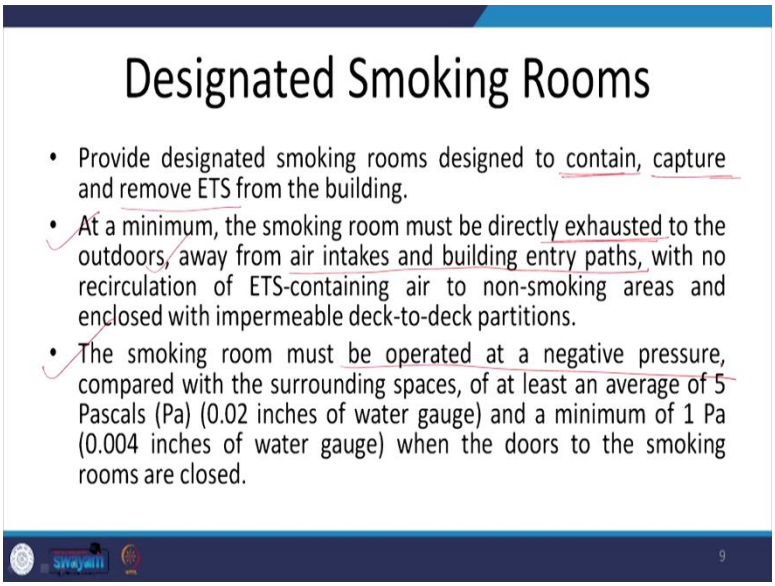

So, when they are providing the designated smoking rooms inside the building; they must be designed to contain, capture and remove environmental tobacco smoke from the building.

So, all these three are mandatory through design passively and with the design of active systems. So, how do we design it? So, at a minimum the smoking room must be directly exhausted to the outdoors. So, no mixing of ventilation system has to be there and this exhaust should be away from the air intakes and building entry paths. So, that this environmental tobacco smoke does not enter into the building again and there should be absolutely no recirculation of ETS containing air to the non smoking areas.

So, we only exhaust. Also the smoking room must be operated at a negative pressure. So, that at any given point of time, the smoke from an from a designated smoking room does not go outside and mix in the other occupied areas which are non smoking.

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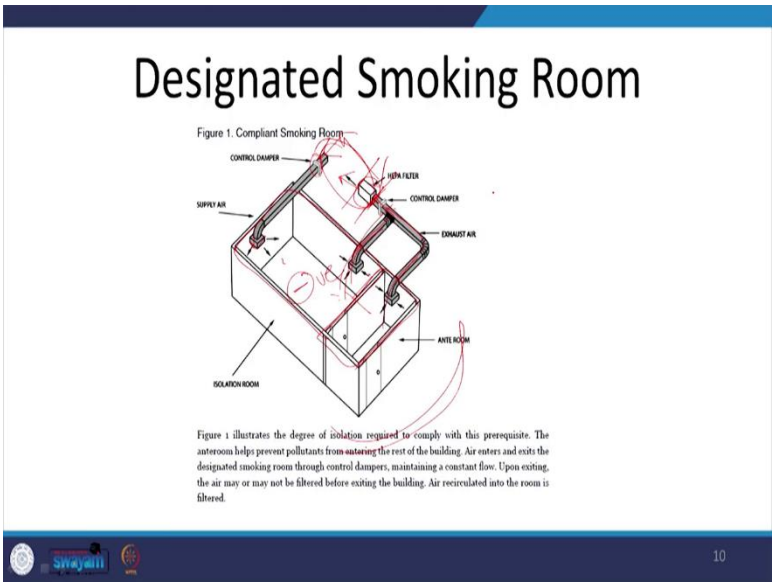

So, this is a tentative design of smoking room. So, we have to design for an anteroom which acts as a buffer between the non smoking area and the smoking zone.

So, this is the smoking zone which is the isolation. Now this smoking zone will have a separate ventilation system which is mainly exhaust, but even before it is exhausted to outdoors; it has to be filtered and then the air shall be exhausted the stale air in the smoke room in the smoke isolation room, there will be a separate supply which will be provided inside and there will be a control damper in case the outdoor air quality is not good it might also call for a filter.

Now, there has to be sufficient distance between the exhaust and the supply. It may be the supply to the smoke room as well as the supply to any other part of the building. So, this exhaust should be at least 25 feet away from any of the intakes building entry or opening. This is how the smoking room has to be designed. It has to be at a negative pressure there should be an anteroom.

So, that no air is exhausted from the smoke room to the outside. So, we are containing it, we are controlling it and then we are exhausting it all three of this has to be achieved through this designated smoking room.

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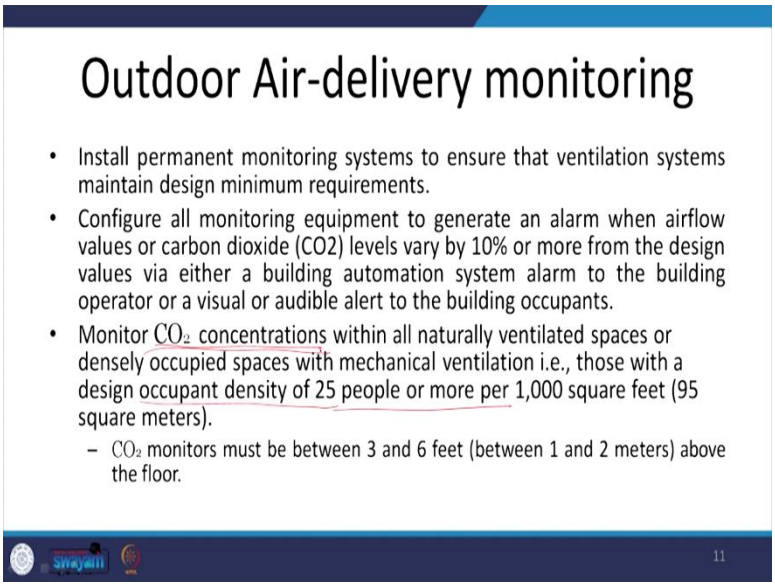

The next is outdoor air delivery monitoring. So, it is not just the rate of supply of air, but it is also the monitoring of the quality of the air which is being supplied indoors.

So, wherever the occupant density of 25 people or more per 1000 square feet is present there; a monitoring of CO2 concentration is mandatory. So, CO2 concentration has to be measured and it has to be maintained within the threshold limits of 1000 ppm. The moment carbon dioxide concentration increases beyond the threshold, 10 percent from the design values an automatic alarms system has to be designed along with this measurement and monitoring mechanism in order to alert the building operators and also the building occupants such that the outdoor air, fresh outdoor air is brought inside and the carbon dioxide concentration levels are brought down to within the acceptable limits.

Another important part of indoor environment quality and management is a management plan. So, we might have systems installed, we might have design done properly and construction happening properly, but the operations require a management plan both during the construction and pre occupancy phases and also the post occupancy phase.

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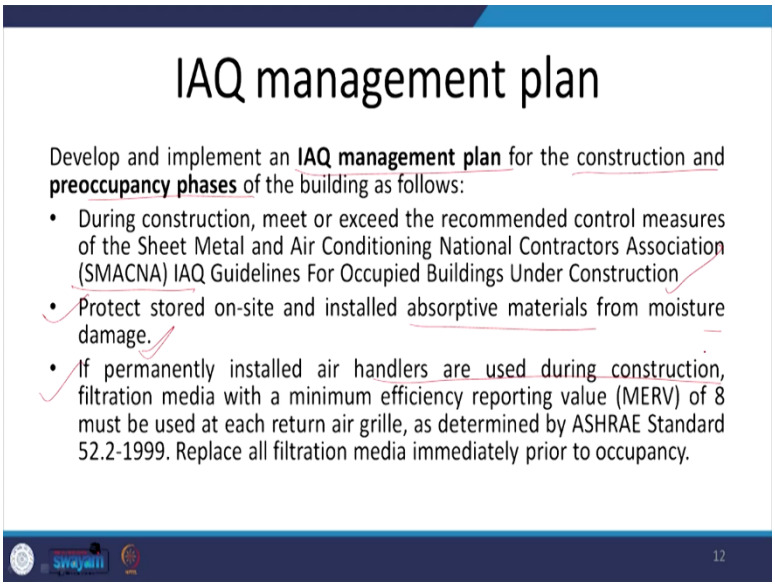

So, here we are looking at the IAQ management plan for construction and pre occupancy phases of the building. During the construction; the SMACNA guidelines for IAQ for occupied buildings under construction must be followed. Now, these SMACNA guidelines largely talk about how this building system shall be implemented, it shall be put in place.

So, during the construction, how the equipment HVAC and ventilation systems, they will be controlled and maintained free from pollutants contaminants. And pre occupancy phases when they have been installed, during the pre occupancy how the cleaning how the cleaning of building indoors interiors will happen. So, all that is given as part of these SMACNA IAQ guidelines.

So, very briefly, we will touch upon what is required for an IAQ management plan. First of all it requires the onsite and installed absorptive materials from the moisture damage. So, moisture should not penetrate the absorptive materials and they shall remain covered and they shall be protected onsite. if there are permanently installed air handlers which are used during the construction; the filtration media has to have a minimum efficiency reporting value which is what we know commonly know as MERV value of at least 8 and this should be used at each return grille.

So, it is governed determined by ASHRAE standard 52.2 and all the filtration media must be replaced immediately prior to occupancy. So, during the construction the filtration media with an MERV of 8 should be there and it should be changed prior to occupancy.

So, the same filtration media will not continue from the construction phase to the occupancy phase it has to be changed.

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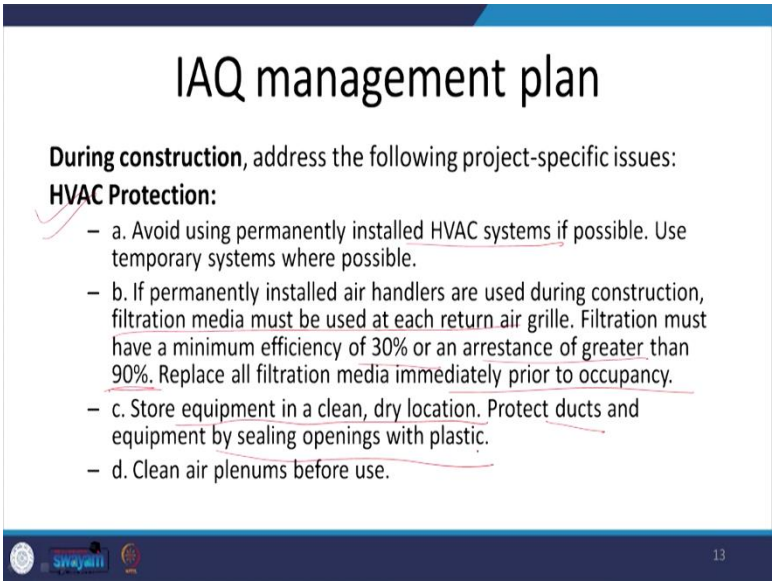

During construction; we have to ensure HVAC protection, where first of all; the use of permanently installed HVAC system should be avoided and temporary systems should be used wherever it is possible. In case permanently installed air handlers are used then filtration media should be used at each air grille which we just a saw with a minimum efficiency of 30 percent or an arrestance of greater than 90 percent. And this media shall immediately be replaced prior to occupancy.

Next is the equipment shall be stored in a clean dry location which is free from dust and any other contaminants settling in the equipment. And the ducts and equipment shall be protected by sealing it with plastic it should be properly covered. And the ducts whatever has been installed the plenums, they must be cleaned before use. So, all of that has to be cleaned.

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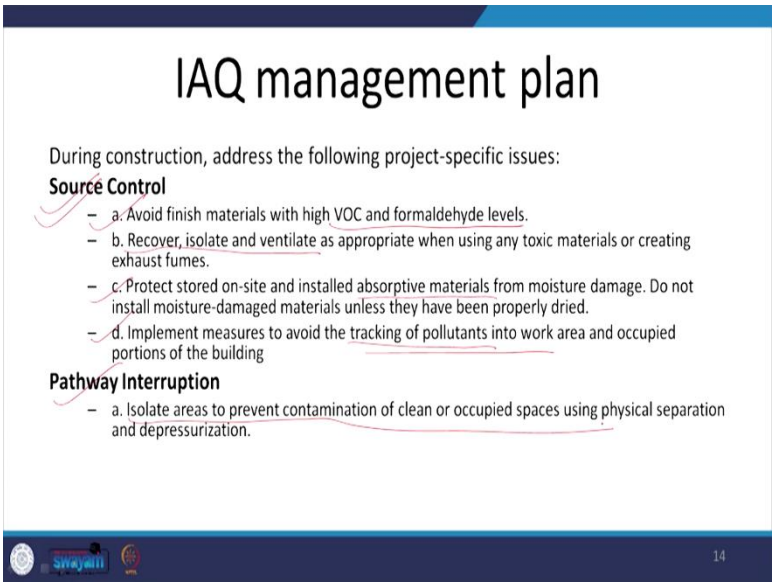

Also during construction; we have to control the source of a pollutants. So, we have to avoid using materials which have high VOC and formaldehyde levels which we have also discussed in previous lecture. We have to in case there is toxic material which is used which is brought then we have to immediately recover isolate and ventilate if there is a toxic material or any exhaust fume are created.

The next is protection should be provided for all the onsite storage and installed absorptive materials from any moisture damage. So, we should not be installing the moisture damaged prone materials before the property has been properly dried and cleaned. And we have to ensure measures to avoid the tracking of pollutants into work area and occupied portions of the building; if there is occupied portion of the building and simultaneous construction going on.

Also, we have to ensure that there is a pathway interruption in order to isolate areas to prevent contamination of clean and occupied areas spaces by providing physical separation and depressurization. For example, what we were doing in ETS control; the designated smoke areas. So, we have to ensure there is physical separation and also depressurization. During construction, we also take care of the housekeeping and there is a proper protocol. So, the work areas have to be maintained dry, the spills shall be cleaned up the potential contaminants such as dirt dust and debris must be controlled and properly covered clean.

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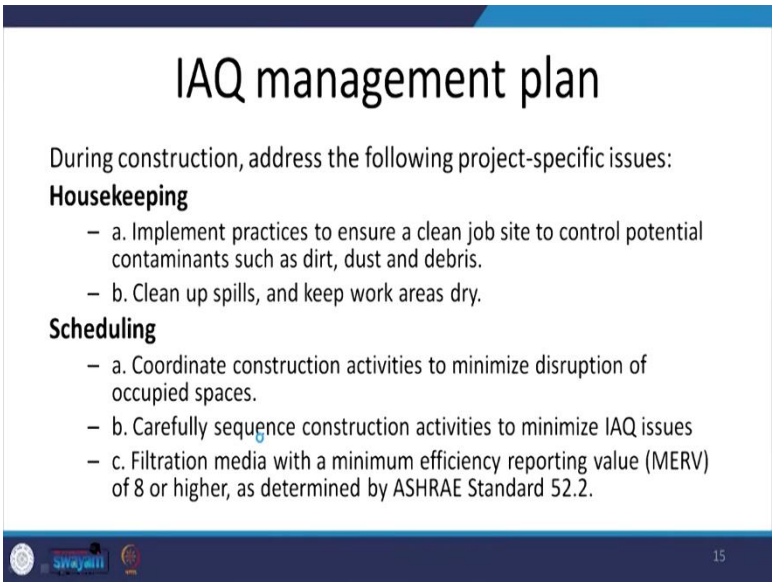

Also, we have to do a proper scheduling such that there is minimum disruption of occupied areas and there is a proper sequence of construction activities which is scheduled in order to minimize the IAQ issues.

Also, we have also seen that the minimum MRV MERV of a filtration media which is required is 8 or higher as per the standard. Now, this is all to be done during the construction. So, it is more of a during construction management plan. But, once the construction has happened and the building has to be occupied during that time from completion of construction to before occupancy the building has to be flushed out.

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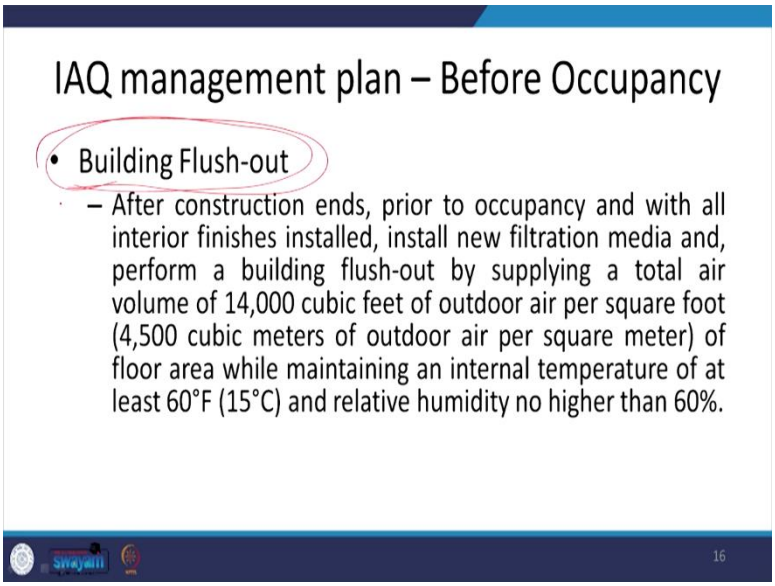

Now, unfortunately, we see that in majority of the buildings because of so much of pressure to complete the construction on time. Most of the time this building flush out is not happening. Now what is building flush out? Building flush out implies that; once the construction has ended and the occupancy has to begin before that all the interior finishes everything which is inside the building will be flushed out by supplying a total air volume of 14000 cubic feet of outdoor air per square feet of the floor area. It is a huge volume of air.

So, the building has to practically keep supplying the fresh air and all the contaminants which have accumulated in the building, in the ducts, in the systems, they have to be cleaned out, they have to be flushed out. This building flush out is very important and it is most important from the occupant health point of view. We might have completed the construction properly, adequately, but, during the construction a lot of these contaminants and pollutants they get they get stuck on the surface of the building finish, that has to be flushed out

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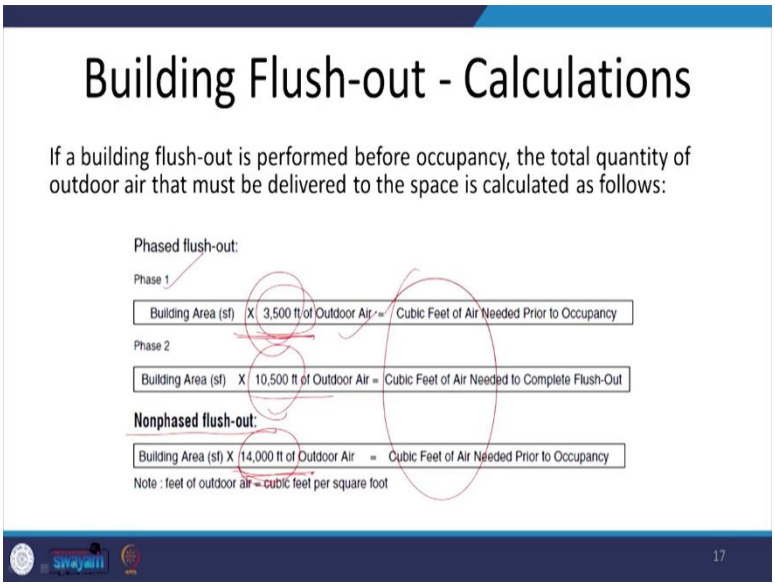

So, in case the flush out has to be planned it can be planned in a phase wise manner in two different phases or it can be a non phased out flush out where we continuously supply the air and just continuously flush it out.

So, in case, it is a phase wise manner; we can plan it in two different phases where the first is a smaller phase where per square feet of floor area around 3500 feet of outdoor air is to be supplied and the flush out happens. And then the next phase begins where 10500 feet of outdoor air will be supply. In case it is a non phase flush out we will directly flush out at the rate which is a prescribed as per the standard which is 14000 feet of outdoor air and the total flush volume of air will be calculated and it will be flushed out prior to occupancy.

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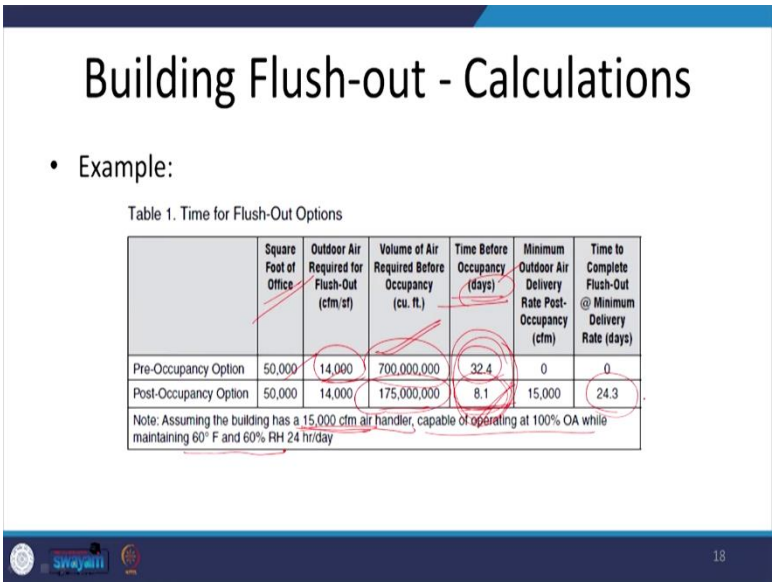

For the given volume of air if we see; the most the preoccupancy and post occupancy options, we see that the flush out at the given rate which is 14000 cubic feet of air for per square feet of a floor area; the total volume which will be required given the total square footage of the built up area and at a given rate of a air supply flush out which is this capacity of the air handler which will be designed for the building as part of the mechanical ventilation system.

Total time, this is in days in occupancy; before the occupancy begins has to be kept for flush out. Now, unfortunately, we do not flush out our buildings post construction and before occupancy. So, here we can see that at 15000 cubic cfm air handler rate which is already there in the building which is capable of operating at 100 percent while maintaining 60 degree Fahrenheit and 60 percent rh for 24 hour per day.

This is the and for supplying total volume of air which is calculated here based upon the rate and area. At least total 32 days of flush out has to be done. Now 8.1 days approximately 8 days before occupancy and the total complete flush out would require additional 24 days of flush out for the minimum delivery.

So, these are the different sections where which are required for maintaining an adequate indoor environment quality. We will subsequently talk about other parameters and other requirements as well which are required for the compliance to green building rating systems and for delivering sustainable buildings. So, we will stop here today and we will

discuss more on indoor environment quality in subsequent lectures tomorrow and subsequently thank you very much for being with us.

Thank you, bye.