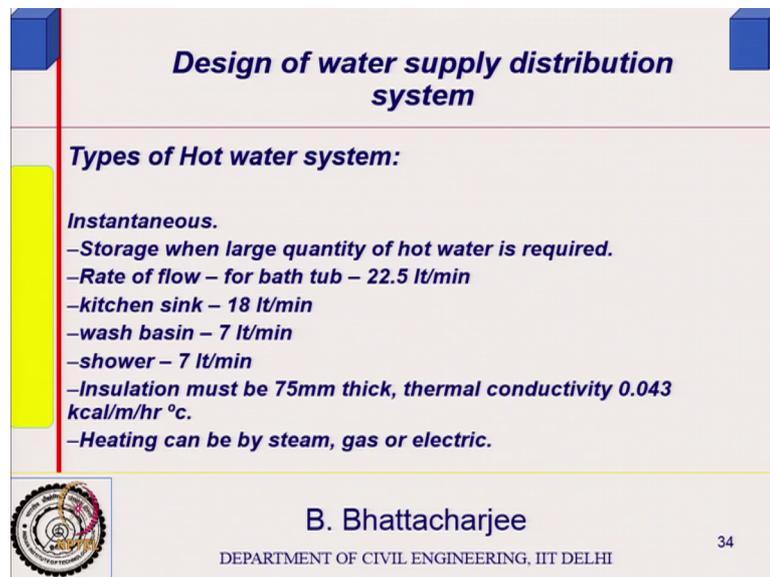


**Fire Protection, Services and Maintenance Management of Building**  
**Prof. B. Bhattacharjee**  
**Department of Civil Engineering**  
**Indian Institute of Technology, Delhi**

**Lecture - 32**  
**Design of Water Supply Distribution System (Continued) and Flow in Waste Water pipes**

So we continue with the hot water supply system.

(Refer Slide Time: 00:22)



**Design of water supply distribution system**

**Types of Hot water system:**

**Instantaneous.**

- Storage when large quantity of hot water is required.
- Rate of flow – for bath tub – 22.5 lt/min
- kitchen sink – 18 lt/min
- wash basin – 7 lt/min
- shower – 7 lt/min
- Insulation must be 75mm thick, thermal conductivity 0.043 kcal/m/hr °c.
- Heating can be by steam, gas or electric.

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34

So, these are the temperature talked about. Now types of hot water supply system we have instantaneous right. Instantaneous is something like this you know and the basically storage is required when large quantity of hot water is desired. For bath of course, is of the order of around 22.5 liters per minute. So, kitchen sink 18 liter per minute, wash basin these are the values given in the code and insulation must be this thermal conductivity. These are also given. Heat in heating can be steam gas or electric anyway the steam is gone, almost you do not see them even gas sitting is very rear. It is largely electric.

(Refer Slide Time: 01:16)

### Design of water supply distribution system

- Piping in hot water supply
- Hot water pipe layout principle, recirculation, air-let off, pressure equalization at mixed fixture etc
- Diagram of hot water pipe layout(SP35 Fig.19 page 88)
- The velocity equation.
- Power required for a pump.

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35

Recirculation is a main thing you know, piping in hot water pipe what are hot water pipe layout principle recirculation? Air let off because vapor should generate and that would create pressure. Therefore, there has to be venting air let off and pressure, pressure equalization at mixed fixtures where you are mixing them, pressure equalization should be there. So, SP 35 figure 19 in page 88 of SP 35, it gives you hot water supply system and it gives you some idea related to power you know.

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### Direct pumping system for continuous demand

The diagram illustrates a direct pumping system for continuous demand. It shows a multi-story building with a terrace, kitchen/bathrooms on floors 1 to 6, and an underground tank. A pump is located in a supply manhole, drawing water from a city water main through a boundary wall. The system includes a cooling tower and an O.H. tank on the terrace.

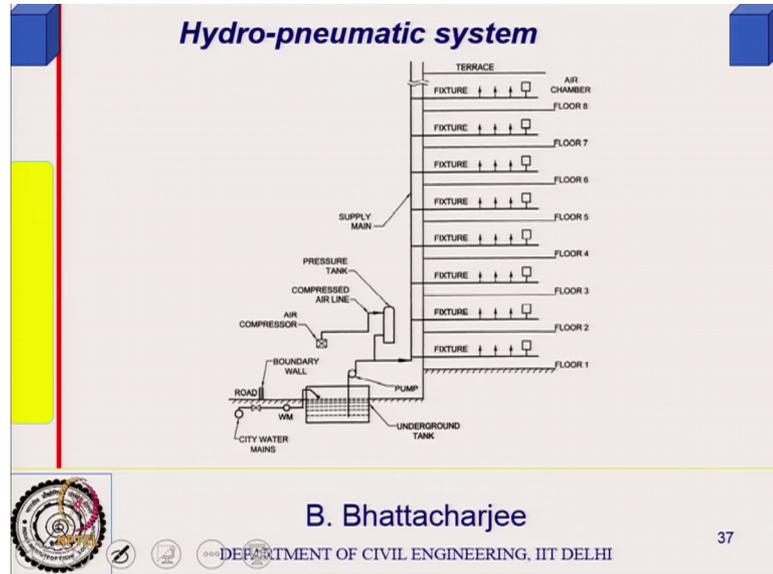
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36

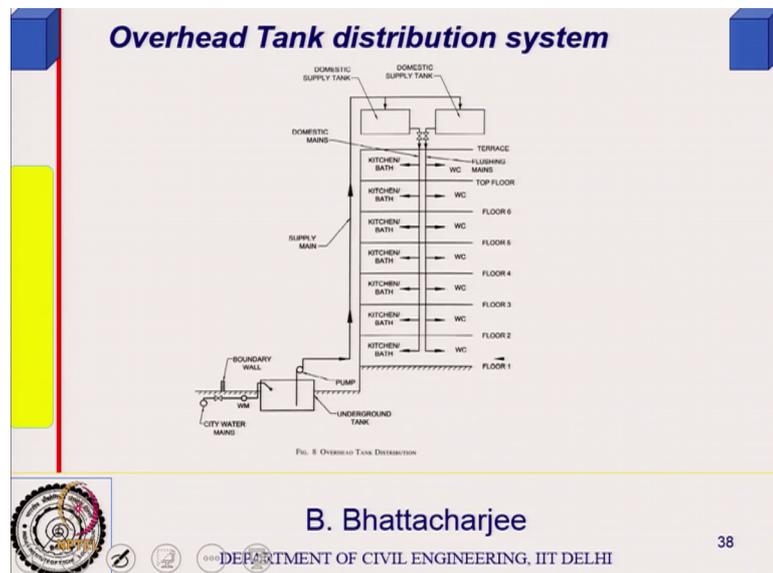
So, direct pumping of this is this is cold water supply system that is been shown and this is hot and cold water supply system.

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This is sorry this the sorry the pneumatic; pneumatic supply system that I mentioned earlier for cold water supply system. So, you have got a pressure tank, compressed air, pneumatic air supply system. So, the earlier I mentioned this given in the code. This diagrams are given in somewhat bigger manner; the terrace the, fixture units etcetera etcetera every floor this given for 12 buildings.

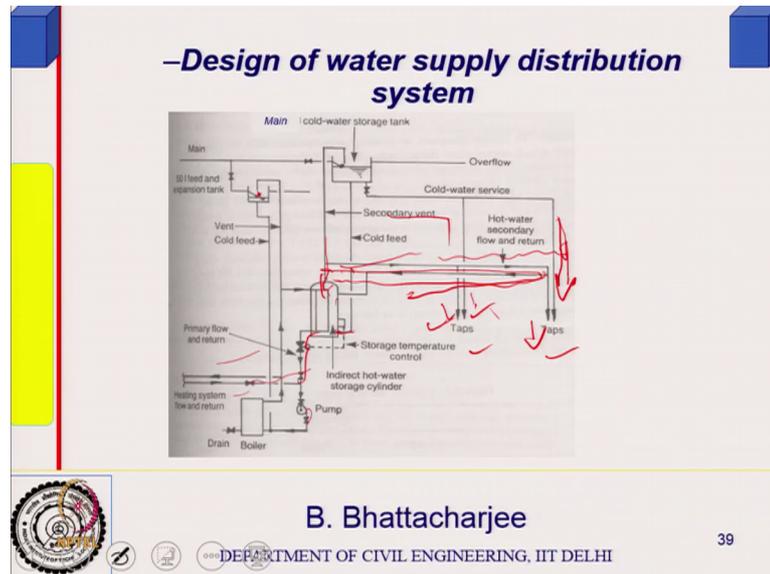
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And this is another one with you know basically two tanks at the top. So, one is constant supply another is.

Student: Built in.

(Refer Slide Time: 02:45)



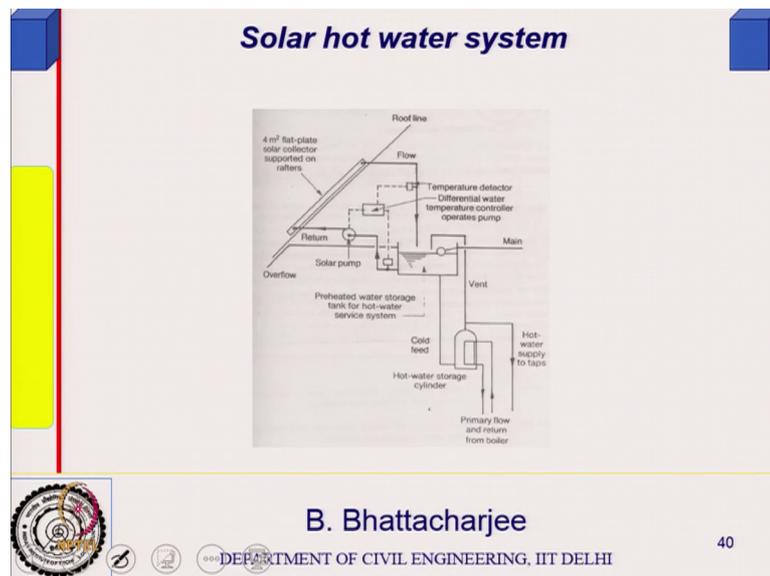
Yeah. So, this like this now hot water supply system as just mentioning something like this. Now if you look at this, first of all I have a you know outside supply is coming something like this right and I might have a boiler here ok. So, cold water cold water enters from this pumped here and this I mean not pumped it is the steam actually. So, this is the showing a steam system. So, the boiler generates the steam the steam moves in this manner and then connected here, steam comes here, heats up the water which is which is directly coming from you know outside which is coming directly from outside the bottom right

So, steam would be heating the water and the hot water here goes up directly supplies through this loop. And there is a kind of you know the cold this, this directly direct supply is there and there is a kind of venting should be there. Cold water, so it does venting is there at the cold water storage tank. So, basically supply is like this, the pressure is not high enough to actually supply the water to the water tank, but it would be venting out because if there is an extra pressure or something; this will release the air.

So, this is obviously, overflow the cold water supply comes here and this the cold water supply in a hot water supply we have loop. So, this is the basically taps, taps here. And there might be cold water supply combined supply, then you might have a cold water tap here, hot water tap here; so, cold water tap hot water tap here. So, hot water is something like this; this is supplied to a loop.

So, it starts from here, boils and then it comes down at the bottom and gets heated up. So, this is a circulation all the time there in case of cold hot water supply system. This is this one is supplying water to the boiler making it steam and the excess water actually you know this goes to again to the I mean the steam goes out and this steam basically any condensed one would be coming to this particular one right ok.

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If you have a solar water heater system, it could be something like this or it is a mixed generally you normally be supplementing the you know. For example, the supply temperature to the boiler cold feed; this is from the solar heater, flat plate collector let us say. So, the hot water because this why thermosyphonic effect is the radiation comes in to it and you have pipes.

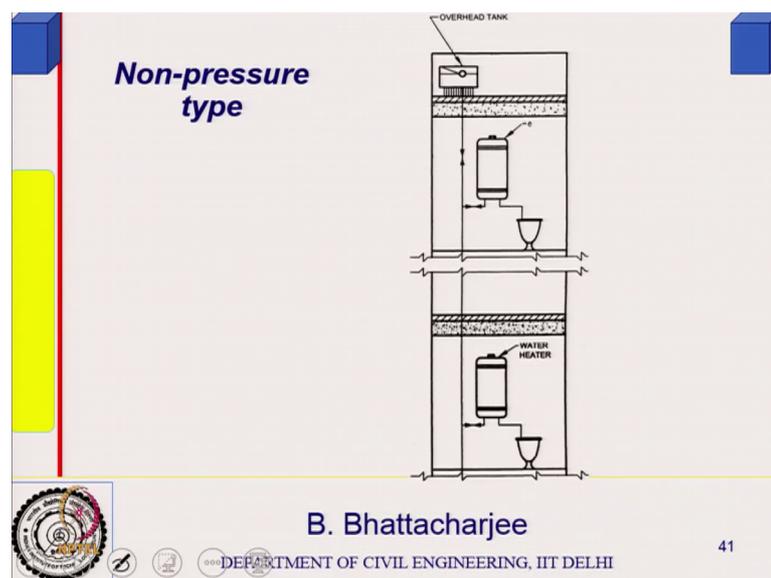
So, this pipes black end pipes usually, the system is there. I think I will the details of this we might may not look into details, but you will have black end pipes put in a kind of insulation and they tried to minimize the convection here. The glass allows solar radiation to come in and trap and this heated up the air around and the pipe black end

pipe which directly receives radiation. Also the hot you know air surrounding, it will heat up the water through this pipe which finally, comes down and there supply water to the boiler is at higher temperature.

Now instead of direct cold water supply to this, so this might be you know so, hot water. So, the air it comes supply water and this is the vent pipe actually as I said, this is the vent pipe. So, from this one the hot water goes and you know recirculated back. So, that is how it is and this is your primary flow. This is the primary flow to the boiler, basically you know the, for heating purpose, the steam generation purpose etcetera etcetera.

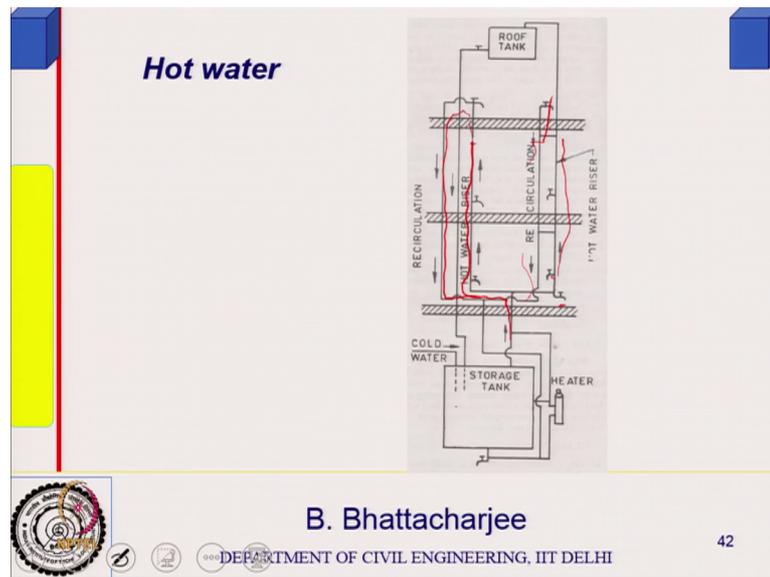
So, cold feed is here, hot feed is somewhere there this goes to the hot water supply and this is for steam generation or heating some sort of heating right and return ok. So, that is using coupling them with a (Refer Time: 07:07).

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Now, there are non-pressure type of geysers which are generally domestic geysers. Code gives you diagrams are those and their classification as well.

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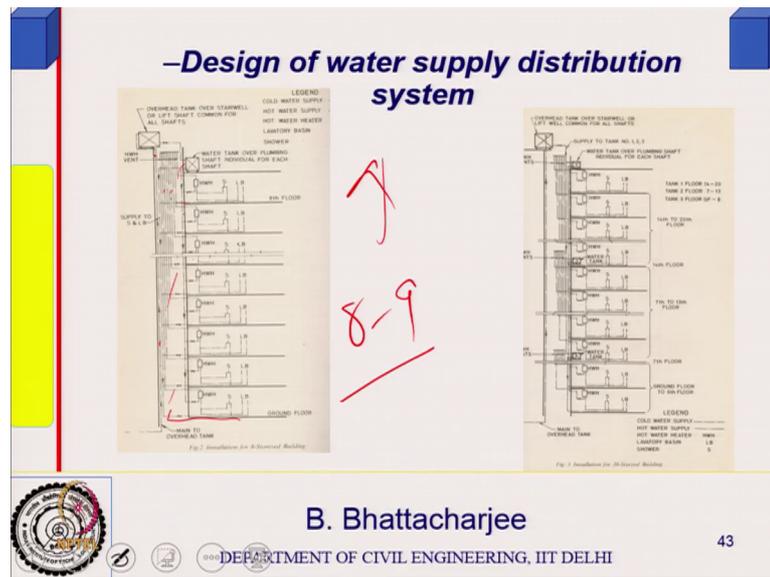
You can look into them. So, this is this is again hot water supply. You have a vent here. The supply path is for example, storage tank, the heater, the storage tank and the heater. So, cold water feed is somewhere there and the hot water goes like this, go in this manner to different floors right. And there is a venting available and the circular recirculated water comes back again to the storage tanks.

Similarly, it goes along this line right and then return is there. So, usually hot water supply will have a complete circuit, return circuit as well because otherwise the pressure would generate and somewhere you have to have a venting up that. So, that excess pressure created by vapors that has to be.

Student: Released.

Released, it has to be released right. So, from the roof tank, the cold water supply would be somewhere there. These are the cold water supply, the cold water supply you know and hot water supply system I mean, there could be there could be you know both hot and cold supply could be the hot water supply system will be through the loop and cold water supply somewhere in between. So, that is what schemes are also given in the code.

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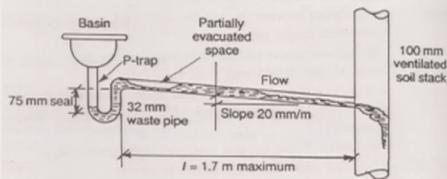
Design of water supply distribution system for hot and cold for large multi storey buildings. For example, this is eight one zone eight storey building. So, all pipes are coming down here, some finishes there, some finishes there and rest finishes there.

So, generally around eight storey or so, eight to nine storey zoning would be there and combinations would be of the similar kind you know, combination of the similar. The non pressure typically in small supply situation, non pressure type of geysers are generally used. So, that is the, that is basically related to hot and cold water supply system and we can now go straight away to look into some issues for drainage system right drainage system.

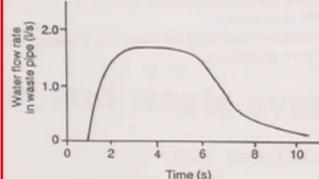
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### Flow in waste pipes

**Random occurrence of short duration.**



**Surges, plugs of fluid. Full & partially evacuated at times**



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2

So, hot water you know drainage system, we can you know look into that. Difference is essentially; first in vest pipes random occurrence of short duration, then sedges plugs of fluid usually partially you know partially filled full not full not full running full, but there are sometime it is full and partially evacuated at times. So, typical diagram would look like this. Suppose in this is a basin, wash basin and you have to have a trap right, water seal. The idea is that no obnoxious gases should flow into the through the space through this control you know, through this through the wash basin. So, usually you will have a trap usually you will have a trap right as a the one shown is p traps. So, you will have some amount of water.

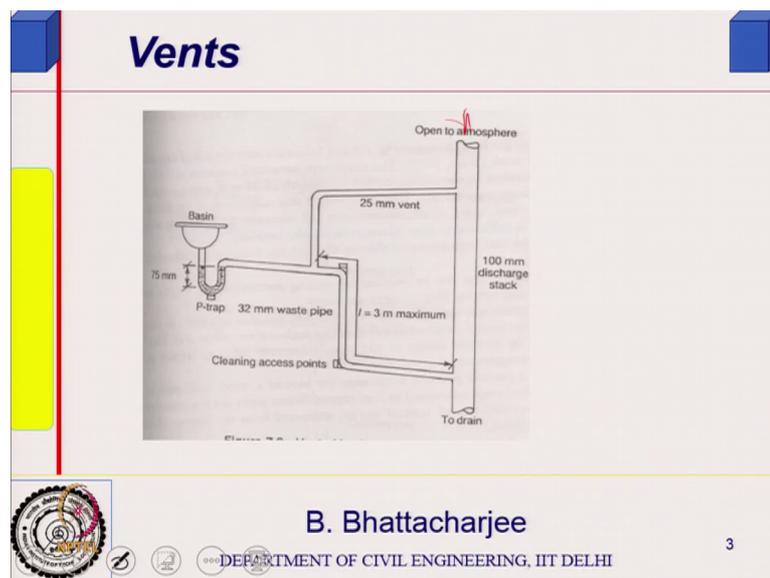
Now the flow would be something of this kind because this a surge like you wash basin you open, suddenly there is a flow right and this flow can result in something of this kind a partial vacuum. You know running full here in this portion full, then there is a partial vacuum and again something of this kind depending upon the slope; the slope is provided usually 20 millimeter per meter or something of that order.

Because gravity flow, there is no pressure here, wash basin is full you know is just some water is coming and it goes like this and then it drops into the main pipes. So, ventilated steck or something of that kind where it goes right. So, the flow pertaining something of this kind and this 7, this minimum seal dimension is actually specified.

So, when flow takes place, it should be such that you know this water seal which is there to stop the obnoxious gases or something of that kind. That should not go away that should not run because that is the partial vacuum created here. So, this should not actually take it away. It might go down a little bit, but then it should come back to its original position.

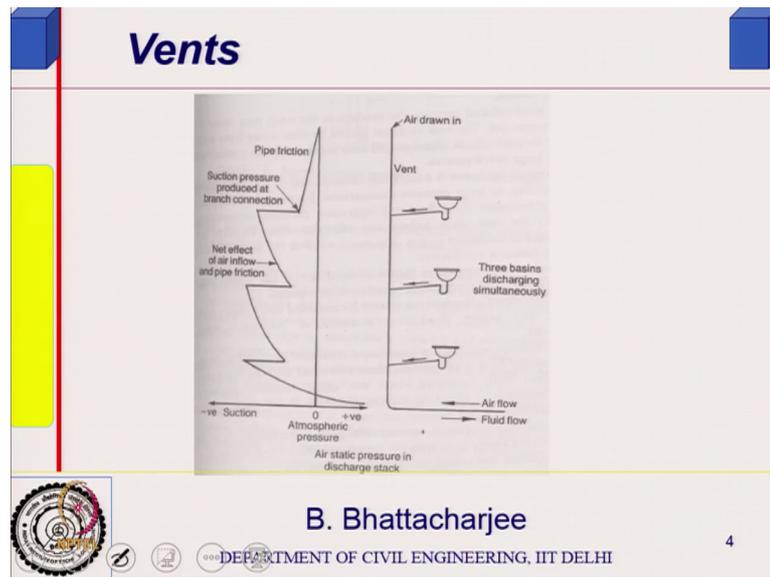
So, these distances are specified something of this kind minimum, maximum distance should be this much slope and so, on and so forth. So, if you look at the water flow rate on this axis versus time, water flow rate increases with time comes to nearly steady value, then it decreases. Water flow rate it is not you know it is not constant from any one of the waste pipes it is not constant. So, there will be so, therefore, there are surges there can be plugs of flow and full and partially evacuated sometimes. So, that is the idea. So, something like this.

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So, you might this avoid this to avoid this kind of partial pressure. You might vent it or it should be a sufficiently large such that the partial vacuum does not pull the water back. So, one of the ways of putting a vent pipe; so, here there is a vent pipe which is connected to the atmospheric pressure. So, when there is a partial vacuum, air will come from this vent pipe and balance this. So, that is the idea. So, these dimensions are also given in the code. So, that this will not run away this seal will not go away. So, that is the idea right. So, vents are provided in order to avoid seal going away.

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So, if you see typically the pressures, supposing there are three wash basins of the similar kind right. So, the if you see the pressure variation, the suction would be created. The suction would be created and this suction increases somewhere at the this line like this. Here the suction is zero, because this atmospheric pressure open and suction is created this gets reduced as it comes down and so, on so forth. So, at the bottom there are some you know there can be even some positive pressure at the bottom as well.

So, pressure variation in you know waste water pipe line could be some. Supposing three of them are flowing simultaneously, then this pressure variation is given. So, this is flowing. So, there is a there is generally like there is a negative pressure in some point, it would be created in the main pipe line and so on.

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## Traps

***An appurtance where water collects. It will normally have a seal. Provided to prevent obnoxious gases from entering. The water seal can be broken by excess pressure or siphon action.***

***–Self cleansing flow to avoid deposition of solid***

***–Requirement of sanitary fixtures in occupancies.***



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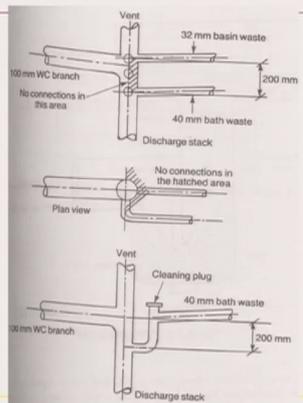
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5

So, traps are provided. They are an appurtance where water collects traps are provided below the fixture. It would normally have a seal provided to prevent obnoxious gases from entering. The water seal can be broken by excess pressure or siphon action. So, therefore, that is to be prevented.

(Refer Slide Time: 14:29)

## Vents



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6

Self cleansing flow to avoid deposition of solid, requirement of sanitary fixture in occupancies are again given in the code. For example, this are the minimum sort of thing. What should be the spacing? For example, this is a branch for water closet. The

distance between minimum distances between other pipes are actually specified in both in the transverse direction. So, this is 200 mm minimum distances between two pipes coming from the same direction. So, these distances are actually specified. So, that there is no cross flow, there is no cross flow right.

So, there is essentially to maintaining maintain basically hygienic condition, the specifications are given and it is largely empirical and hardly anything to do you know not really calculation based on anything of that kind. All though over all sizing would be may be of a combined COR can be based on some calculation; combined COR line of rain water as well as you know waste from domestic waste and all.

Say like the one connecting from some of the houses in the campus to the you know, to the main pipe going to the municipal drain that may you might calculate that. If it is combined, then rain water as to be also calculated, but usually their significantly over designed. So, they have based on experiences on the largely, but whatever the design issue there; then will look into also. So, this demont space distances between different pipes different connections. These are specified some of these sizes are also minimum specified.

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**Basic Principles**

- **Self & induced syphonage**
- **Blow out & Surcharging**
- **Cross flow**
- **Evaporation, leakage & wind effects**
- **Bends and offsets**
- **Intercepting traps**
- **Rain water in soil stack**
- **Pumped or pneumatically ejected lifting**
- **Capillary.**

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7

Basic principle is that it should be you know avoid syphonages of all kind, no surcharging, no cross flow, evaporation, leakages and wind effects should be taken. It should not be happening and bends and offsets should be as per the distances specified,

then there can be intercepting traps that comes of course, of the ground level. Because you know where you have like a pipe from a house connecting to the municipal main or the local main. There will be providing a intercepting you know interceptive intercepting men I mean joints basically or traps.

Rain water in soil like the trap in trap below the sink, you have a trap below the sink kitchen sink. It never discharges directly on to the pipe because you want to release the pressure. So, you have a trap where you allow a mesh you know sort of allowing only to water to go or may be fine materials, but not ready larger materials. So, even in the sink bottom you have a kind of a trap.

So, the traps are these are the intercepting traps are generally provided, it will equalize the pressure and you can have rain water and salt stack separate or stack separate or they could be combined generally separate rain water and soil stacks are separate. Some cases you have in the in the you know in states pumped and pneumatically ejected lifting etcetera the capillary actions can also be there.

So, anyway the basic principles are something like this. You got to avoid self syphonage self an induced syphonages, blow out or surcharging that is cross flow has to be you know and leakages etcetera has to be avoided.

(Refer Slide Time: 18:14)

**Flow in waste pipes**

**Drainage installations shall remove effluent quickly and quietly, be free from blockage, durable & economic.**

**To maintain flow & avoid deposition:**

$$\frac{L_e}{G} = 35^2; L_e = L + 5$$

$$G = \frac{h}{L}$$

*Handwritten notes: Lp Le (34)*

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8

Now, basic idea is that drainage installations shall remove effluent quickly and quietly, no it should be noise free be free from blockages, durable and economic. So, self cleansing to have self cleansing flow, no deposition. This an empirical formula available where  $G$  is the gradient given by head available and length ratio of head available by length and  $L_e$  is the  $L$  plus actual length plus 5 actual length plus 5. So,  $L_e$  by  $G$  should be now actually  $h$  should be more right because you want to have the self cleansing. So,  $L_e$  by  $G$  would be basically  $L_e$  is  $L$  plus 5. Now this is  $h$  by  $L$ . So, this should be you know, this if this is 35, I mean 34 let us say, then if I want to you know if it is if  $h$  is more this would be.

Student: (Refer Time: 19:29).

Yeah this would be less, if  $h$  is higher than this would be less this would be  $h$  is higher than this would be less. So, it is suggested that this should be you know 35 square or it should be around 35 may be lesser than this. Because  $L_e$  into  $L$  divided by  $h$  that is what it is coming  $L_e$  into  $h$  divide by  $L$  divided by  $h$  or  $L_e$  into  $L$  divided by 35 square. So,  $h$  should be greater than that not less than that, again it should be too large because noise and other issues comes into picture. So, this the guideline given to start with this is the guideline given right; not in the code it is not from the code. It is from some of the services book some literature British literature, you find something or similar kind.

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## Traps

- water trap** ✓
- Flow under gravity** ✓
- Vent pipe (parallel stack is provided). (a sudden flow of water through main pipe can result in a partial vacuum in the pipe leading to the water seal being sucked out. Vent pipe ensures that the atmospheric pressure is maintained and vacuum not created. Or the size of main pipe has to be large vent pipes are meant for avoiding siphonage).** ✓



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9

So, that is some guidelines right and essentially national building code will look into how it calculates out. It is you know largely empirical right, largely empirical. Now traps are water trap flow under gravity that is what we said vent pipes should be there. Parallel stack is provided a sudden flow of water through the main pipe can result in a partial vacuum that we have seen leading to water seal breaking out. Vent pipes ensures that atmospheric pressure is maintained and vacuum is not created. Or the size of the main pipe has to be large enough; so, that the pressure is maintained atmospheric.

(Refer Slide Time: 20:55)

**Traps**

- Two pipe system.**
- One pipe system.**
- Single stack system.**
- Partially ventilated system.**

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10

So, there are something called two pipe system. One pipe system and single stack system and partially ventilated system; some of them have become actually obsolete. But anyway let us since the code gives you I will give you the definition somebody might use it in some innovative way.

(Refer Slide Time: 21:15)

## Traps

- **Two pipe system:** Separate pipe for soil and waste water and are ventilated separately.
- **One pipe system:** one pipe that is ventilated is connected to sewer main – waste water pipes are connected through traps.
- **Single stack pipe:** in most popular nowadays since it is economical. (table 56)

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11

What is the two pipe system? You separate out the soil and the waste pipe separately. Separate pipe for soil and waste water and separate vents also. One pipe system is that is ventilated and connected to the

Student: (Refer Time: 21:30).

Sewer mains. So, it is one pipe waste water pipes are connected through traps of course, this is the most popular that is single stack systems.

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## Two pipe system

The diagram illustrates a two-pipe system in a three-story building. It shows two vertical stacks of pipes. The left stack is for soil (Wash Basins, Sinks, Baths) and has its own vent pipe (MVP). The right stack is for waste water (Wash Basins, WCs, Urinals) and has its own vent pipe (MSP). Each floor has an 'ACCESS' point. The pipes terminate at a 'TO BUILDING DRAIN' at the bottom.

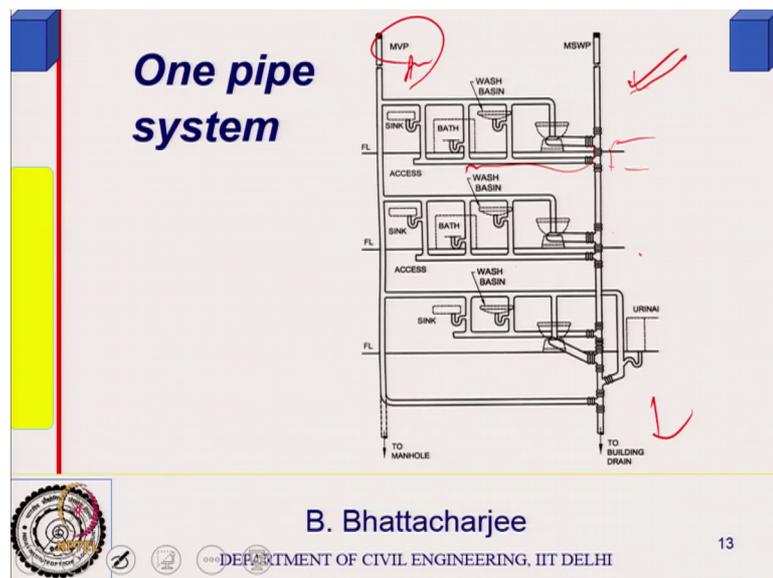
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12

So, let us see diagrammatically this is given in the code; two pipe system would look something like this. So, these are the WCs and they are connected to they are connected to a separate pipe because this two pipe system and this is vented also independently.

Each of them are vented independently, each of them are connected to the vent system right. So, this is this is you know this separate system and this waste water system. So, you have got wash basin bath etcetera etcetera and this is also vented separately. This is you know this collected separately and this is vented separately. So, each of them are connected at the top to ensure that the seal remains there you know they connected separately. For example, from wash basin pipe there will be connections. So, that you know atmospheric pressure is maintained here and it is not partially evacuated at any time.

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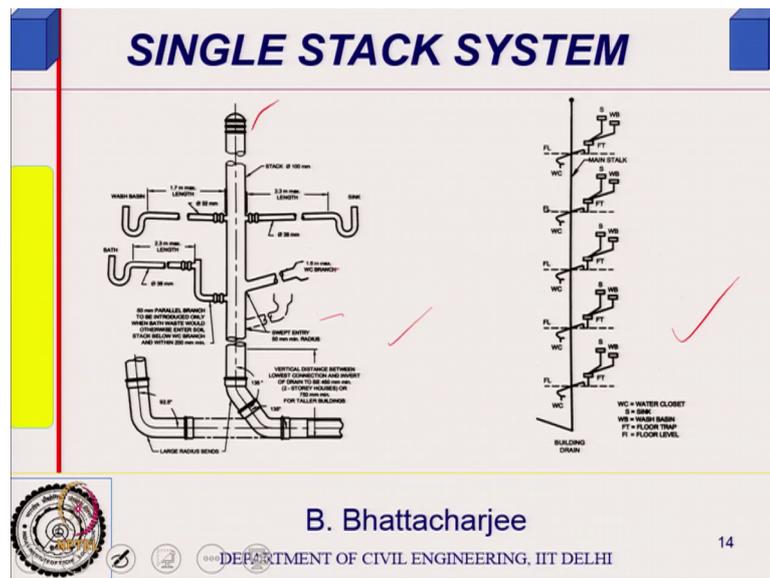


That is two pipe system I think, this is my one large not used most of it because quite uneconomic you know complete two pipe system for soil and stack. So, then they there are and, but then one pipe system you have to maintain this distances between you know various connections and guidelines are again given. So, you have everything in single one and a single stack, but dimensions and distances between you know soil discharge and waste water discharge and their you know at depend depending upon you know like. If they are in the same direction coming from the same direction or otherwise this

minimum distance to be maintained is given for example, that should be cross flow like this.

So, that is what is about. So, guidelines are given, but here we use only one vent main you know mains soil are waste pipes. So, this is a main pipe and this is the main vent pipe MVP is the main vent pipes. So, that is the idea.

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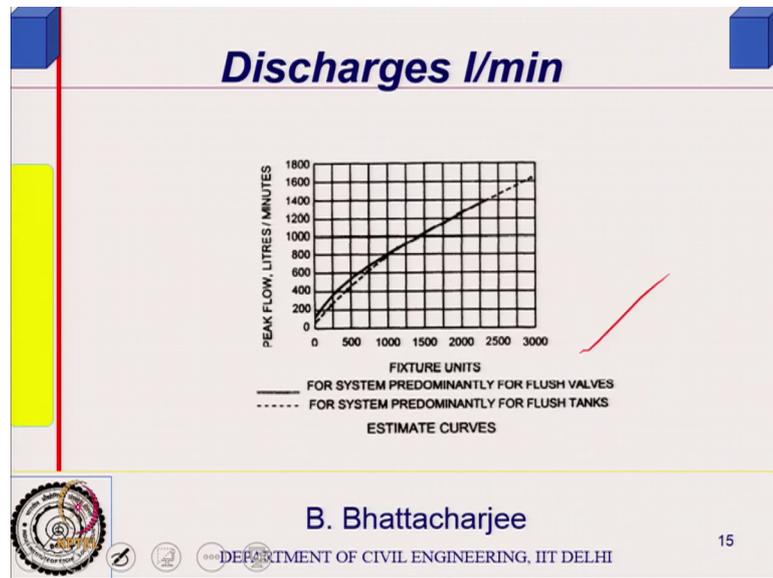


And single stack system come you know it uses one stack, but large enough. So, it uses one stack large enough where discharges are again the distances are specified distances are specified. So, single pipe x has a vent pipe because it is sufficiently large the pressure within it is almost atmospheric most of the time. So, anywhere any kind of you know like partial vacuum the air from here would actually ensure that you know that there is there is no partial vacuum created all right.

So, this is what it is showed national building code gives you this kind of diagram this diagrams are etcetera etcetera. So, that is the idea. So, idea in an guidelines are this hardly anything to be done minimum size of this are specified and distances are specified. So, it is look at the table or look at the guidelines given and just design accordingly and this becomes more than standardized.

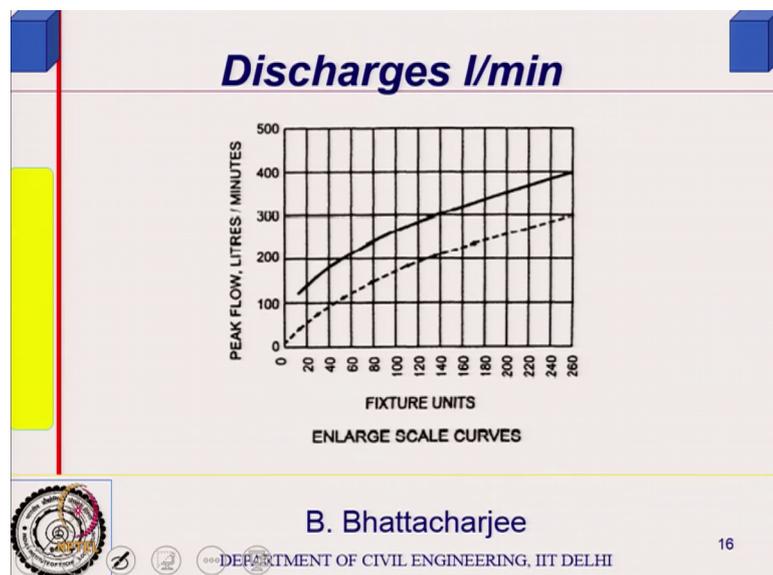
Now you want to calculate out for number of them joining, then you may have to do some sort sorts of pipe sizing or single building you do not have to do much, number of them are joining.

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Then you calculate out the fixture units. Now fixture units for each of them are again given for you know the waste pipe for the wash basin or waste pipe from a bath tub. So, they are it is the fixture unit values are given. And then for fixture units peak flow in liters per minute is given through this graph.

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This portion of the graph is separately given in this manner and then it says the pipe sizing is given in a table SP 35.

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The slide is titled "Hot Water supply" in bold blue text. Below the title, there are two bullet points: "-Pipe sizing and layout Table 52 of SP35" and "-Sizing of rain water drain pipes (table 57 in SP 35)". A red vertical line is on the left side. A yellow vertical bar is on the left side. A red handwritten note "Ria" is written above a red diagram of a pipe network. The diagram shows a rectangular layout with several circular nodes representing fixtures. At the bottom left, there is a circular logo of IIT Delhi. At the bottom center, the name "B. Bhattacharjee" is written. At the bottom right, the number "17" is displayed. The text "DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI" is written at the bottom.

Pipe sizes are given in a table in SP 35. So, you do not have to play around much with it. It is only for similar you know situations what is the fixture unit corresponding to pipe sizes. And rain water drain pipes are also given in table. Now rain water drain pipes will come separately. So, this pipes are given in tables, this is the fixture unit, this is the pipe size that is it. So, no it is not I mean possibly it is possible to model the flow system and get your pipe sizing also, but since a safety is very you know hygienic safety is a major concern, it is the guidelines are straightway given. And therefore, you know, you do not have to do any calculation or anything of that kind simply look from table 53 of SP 35.

When it comes to rain water drain sizing which is separate; however, for combines your main lines one may use, but you can see if you have if you have by chance had a chance to peep it into a sewer line, let us say the one going in a IIT from by the hostel side because one of the one of them connects to the municipal drainage system in the Gamal Abdel Nasser Marg. That is your outer ring road. Now these days what they do is they also lay network cable at the top many cables at the top of them. The pipe size will be something of the order of diameter of may be 2 to 3 meters means highly over designed usually highly overdesigned because you do not want to take any risk and it might be combined rain water plus.

Student: (Refer Time: 27:25).

So, therefore, rainy season it will have large might have large flow, but it is usually large over and as I said its typically they put it into the sewer. You might have seen in some movies, surely you would some in some movies. It is not only at bottom, there is some amount of water. It is never running pool, so it is highly oversized. So, therefore, sizing is not a big issue you might use Manning's formula to calculate out with the coefficient etcetera etcetera. But finally, the values are you know guidelines are given.

So, rain water drains, how do you find it out? Supposing you want to do rain water again this is tables are available, tables are given. This table 57 in SP 35, it gives you rainfall intensity and the area you want to cover rainfall intensity that is millimeter per hour right. So, it is essentially how much rainfall intensity is there. So, the discharge depend upon that and pipe sizing's are supposed to cover this much area, there is one drain here, one drain here.

Let us say one drain here you know the drain pipes take in the water. So, this sizing would depend upon area as well as the rainfall intensity. So, the table gives you the values again no calculations straight away the tabular values you can take. So, that is how actually we do drainage you know drainage and waste water supply and all that.