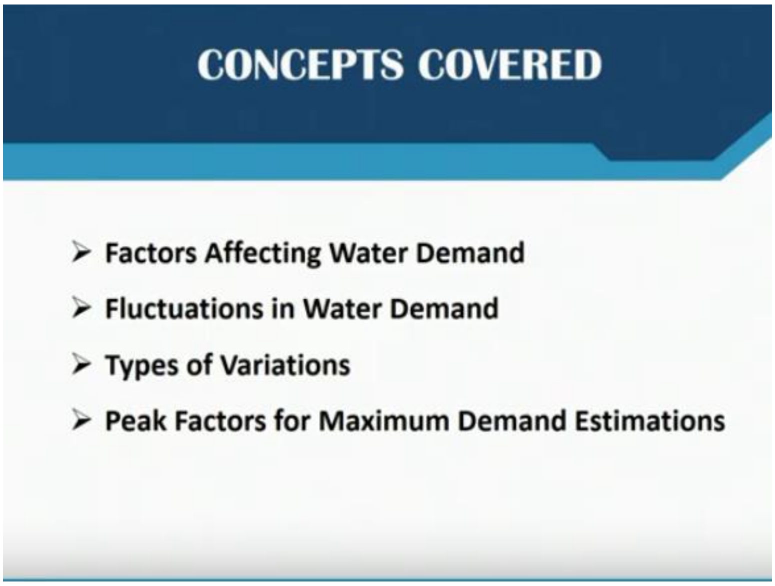
Water Supply Engineering
Prof. Manoj Kumar Tiwari
School of Water Resources
Indian Institute of Technology-Kharagpur

Lecture - 08
Fluctuations in Water Demand

Hello friends and welcome back. So we have been discussing about the water demand this week and in previous two classes we talked about what are the basic concept of water demand and what are the various types of water demand and under these various types of water demand, what are the different components of the water demand.

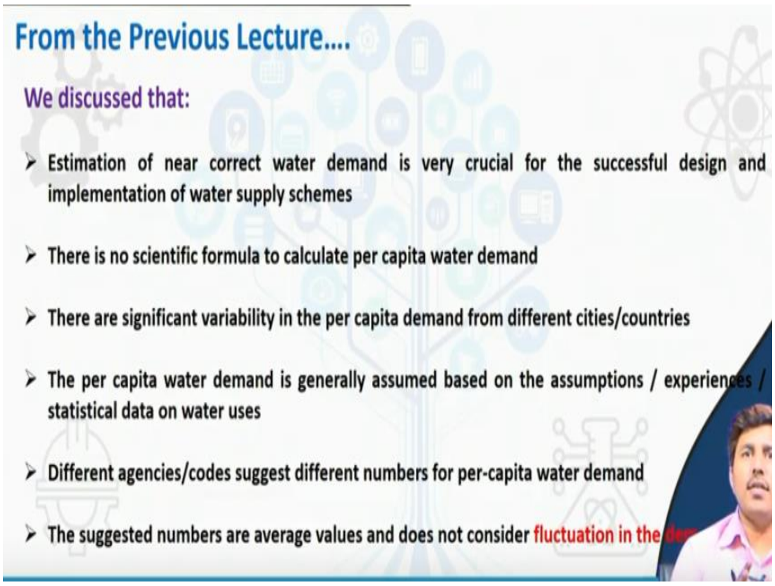
So we did discuss about the per capita domestic demand and institutional demand industrial demand and firefighting demand and how these demands are estimated based on the numbers or data that is suggested.

(Refer Slide Time: 00:53)



This particular class we will be talking about the fluctuations in the water demand basically and the things that we are going to cover or discuss is the factors that affect the water demand. Then what leads to fluctuation in the water demand. What type of variations we see in the water demand and what are the peak factors that are considered for the demand estimation.

(Refer Slide Time: 01:26)



So far we have been discussing about the different components of water demand and in previous class also when we talked about the numbers that come from different agencies, we see that there is substantial variation in the number and these variations are essentially because it is practically not possible to estimate water demand in a very precise way, okay.

So what we discussed is that estimation of near correct water demand is very crucial for successful design what we discussed in the very first lecture of this week, but unfortunately, there is no scientific formula to calculate per capita water demand correctly. It cannot be okay it is a very variable nature of a variable nature of kind of a number and which is very difficult to estimate that, almost impossible.

So there are significant variability in the per capita demand which we see from different cities or different countries. The per capita water demand is generally kind of assumed based on certain assumptions or experience or the statistical data on water uses what so ever is available. And we also saw that different agencies or regulatory codes suggest different numbers for per capita water demand.

Now this primarily is because the nature, very nature of this property of the requirement of water imposed or posed by the per person and this leads to a kind of the nature of the parameter is as such that it leads to the substantial fluctuation in the number that comes out and the kind of water that people consume on day to day basis.

(Refer Slide Time: 03:23)

So if we see what affects the per capita demand, there are a list of factors which can affect the per capita demand. It is affected based on the size of city and this we discussed in detail in the previous class as well that all the regulatory agencies through different numbers for per capita demand for different type or different sizes of the city, okay. For Metropolitan the number goes as high from 150 to 200.

For cities, moderate type cities, it goes somewhere 135 or around 150. For small towns it is hundred or four even smaller towns it can go less than hundred, okay. Then there is a presence of industries. If there is presence of industries or in industrial town the demand is different okay. Not demand from industries but demand from the person as well okay.

The domestic demand can also vary depending on the availability and nature of the industries present in the system. Climatic condition. Again a very important factor, okay. It is obvious that in if there is a hot summer people consume more water, people drink more water, they become thirsty pretty often. If it is chilling winter, the consumption of water for drinking purpose reduces, okay.

Similarly, like it is not just about the drinking purpose, it is about cooking, the kind of cooking goes in the summer the kind of cooking goes in the winter might be of different nature. In monsoon season, your outdoor water requirement, irrigation, gardening, those requirement is almost reduced to a drastic scale okay because there is substantial water in the form of rainfall.

So you do not need to kind of water your plants and those things, okay. Particularly if you talk about Indian conditions, so in hot climate people take baths twice, thrice in a day okay and that too spend substantial time under showers. Where as in winter, you will just go into the bathroom for a few minutes and then come out.

So the amount of water required for bathing purpose which is one of the most dominating in house water use as we discussed in the previous class as well can vary substantially based on season to season. So the climatic conditions plays a very important role. Habits of people, okay. Again, it is a very subjective but it does play a role okay.

Habit of people means as a society, what is the cooking habit whether cooking is done on a daily basis okay. In western countries generally cooking is done many times, cooking is done only on the weekends. So almost no demand for cooking over like span of four or five working days. Most of the cooking is done in the weekends. Whereas you may as a society or people may have a habit of cooking daily.

Bathing habits, okay. And so all these like the kind of people behave in day to day life, the water requirement may change. Then the economic status of people. This also we discussed that particularly if people like if water is planned for a high-end society, generally the consumption is more. So if the economic status is high, again you can correlate with the correlate with the habit of people as well.

So for high economic societies, people use more of the like not much work is done from the hand. So they will use the dishwasher, they will use the washing machine, they will use the Jacuzzi, shower, bathtub and maybe swimming pool for bathing purpose. So the kind of lifestyle changes with the economic of people and that largely affects the water consumption.

Quality of water is another important parameter. If the water quality is good, it is likely to be like people will use more water because they are not concerned about the quality they presume that water is safe, but if the quality of water is bad, if you are getting silt in your water, so nobody can use, nobody will like to use that water in shower because all silt will go all silt sand will go to their heads and their body.

So maybe if you want to take a bath, you will just fill a bucket leave it for five minutes when silt settles, you will take the supernatant and use that water for bathing purpose okay. So the quality also plays an important role in purpose like cooking, bathing, cleaning of various like utensils, cleaning of clothes, floor cleaning. So all this will like depend on the quality of water as well.

Hours of supply okay. If water is supplied intermittently, the consumption pattern may be different to the one where the water is supplied in a continuous system like 24/7 supply systems. So if water is being supplied around the clock, the consumption pattern might be different whenever you open tap you are getting like direct supplied water.

In case of intermittent supply, the people actually kind of fill the water tanks or have in-house storage systems to fill the water and then use it over a period of time when there is no direct supply is there. So that way the uses also becomes like variable. Then pressure in the distribution system, again a very important parameter. If the pressure in the distribution system is very high you will get lot of flow.

So if you open tap for two minutes, you may actually get some say 40 litres water. If pressure is very low you may open tap for two minutes you may get just 15, 20 litres of water. So if you are spending two minutes under shower the amount of water that you are actually consuming is more than double. If you are opening say basin tap for just a minute, you may actually use more amount if the pressure is high.

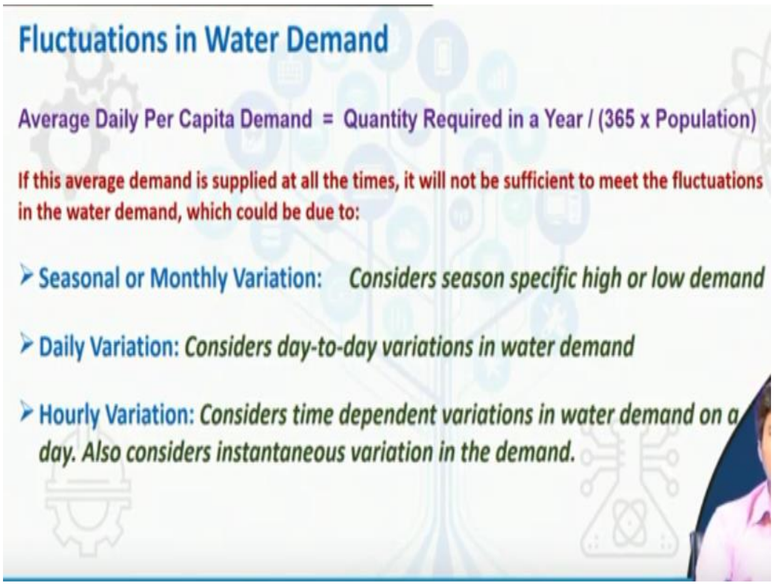
So pressure in distribution system also plays a important role. There has to be adequate pressure but excess pressure will kind of lead to more water consumption. Efficiency of water work administration. So like if there is any issue, problem, pipe breakdown those kind of thing if utilities is quite efficient in handling the complaints and managing these things the water consumption is generally on higher side.

If utility is not that good, if your pipe broke down and you are you are having no water in your home for two, three days, of course your water consumption is going to be less, okay. So that is another factor. Then cost of the water. In India we do not value water that much. The cost of water in various cities is still very less okay. Whereas in developed countries there is substantial cost of water and people.

This could be a very important factor for controlling the demand if the cost of water is high. As for any other product, if the price goes up, the demand comes down. If price comes down the demand goes up. So similar thing can happen with the cost of water. Of course, the basic minimum requirement people will still use even if it is available at higher cost.

But many other uses, avoidable uses people tend to avoid if the cost of water is high. Then policy of metering and charging method which again is related to the cost of water, like if cost of water is high and there is like metered consumption and proper billing and charging is being done. So that can actually regulate the water consumption to certain scale. So these are some of the guiding factors.

(Refer Slide Time: 11:46)



There could be a few more guiding factors on the water consumption, the few more factors which kind of affect the water consumption. But these one are the basic factors. Now when we say that water demand or water consumption depends on these many factors. So obviously, there will be lot of fluctuations in the water demand.

Now generally, when we say that okay, like we were saying that 135 lpcd water in earlier lecture for design purpose. So these numbers that we get or the different agencies that number that they suggest, is not the water requirement on day to day basis. It is the amount of water consumed over a period which is averaged over daily scale.

So maybe like if you see the total if you have a water utility, which is pumping some amount of water in a town and it knows that okay, it is serving say n number of people there, so you know the population, you know how much amount of water is being pumped into the society so you can get an average per day per person consumption okay. And that is how we get the average daily per capita demand.

So the quantity of water required in a year or over a 12 months period and then you divide that with this 365 days in a year and multiply that and by the divide that by the population as well. So when the total consumption in a year you divided by 365, you get total average consumption in a day by this total society or total city and if you divide it with the population as well, so you get the average daily per capita demand.

Now this average daily per capita demand does not mean that the same amount of water people will be using on a daily basis. It is an average number over a span of year or say six months or more than a year at times in fact. So the demand is estimated based on the total consumption over a largest unit of time and larger unit of population.

And when we divide it with the time and population, we get the average daily per capita demand. But when we precisely plan a utility, let us say we figure out that okay this say a city needs hundred liters per capita per day water and there are one lakh people. So based on that, we need say, thousand million, there is one lakh people and hundred so that means we need 10 million litres of water per day, okay.

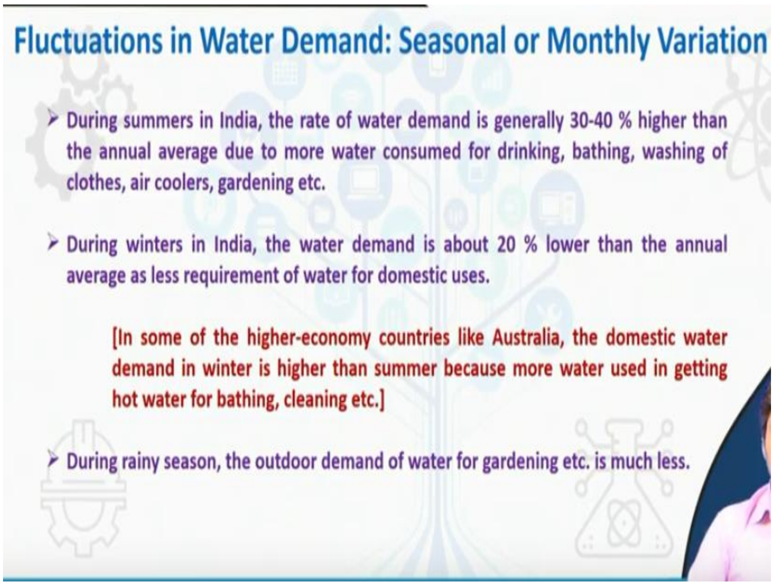
But if we plan a system which can deliver 10 million litres of water in a day, it will work very well on the average days, but when if there is a requirement someday, it is not that requirement will always be 10 million litres per day as we were just discussing there is going to be seasonal variation. So in winter period, we may see the requirement is just say 60 million litres per day or 80 million sorry 6 or 7 million liters per day, okay.

So that means, your system will still be able to kind of fulfill the requirement. But, in summers the requirement may shoot up to 12, 14 million litres per day. Your system is designed for a 10 million litres per day flow. It cannot provide 14 million litres per day water and then your system is going to fail.

So if we do not account for the variations or what amount may needed on a, when basically maximum water is needed, our system might not be able to fulfill that maximum demand. So as a designer or as a engineer, one must consider these fluctuations in the demand and the major fluctuations are of three types, there are seasonal or monthly variations. So this is primarily based on the climatic conditions.

There are daily variation, which is basically day to day variation in water demand and there are hourly variations, which basically considers the variation in a water demand within a day. So within a day when there will be time when the water demand like in the morning hours when people take bath you consume more water. In the afternoon, there is no cooking, no cleaning, no like bathing activities, water demand is very low. So there is hourly variation in the demand as well.

(Refer Slide Time: 16:49)



And when we plan or when we plan to kind of conceptualize a water utility or designer water supply system, we have to consider these fluctuations. So if we talk about seasonal or monthly variations, so during summers in India the rate of water demand is generally 30 to 40% higher than the annual average due to more water consumed in drinking, bathing, washing of the clothes, air coolers, gardening all these activities.

Summer is a dry season, so lot of water goes to the like gardening, okay. Our clothes get wet by the sweat or other things pretty frequently. So frequency of washing cloth increases. The requirement for air cooler increases. The frequency of bathing increases. The amount of water that people drink increases. So overall 30 to 40% higher water consumption could be there.

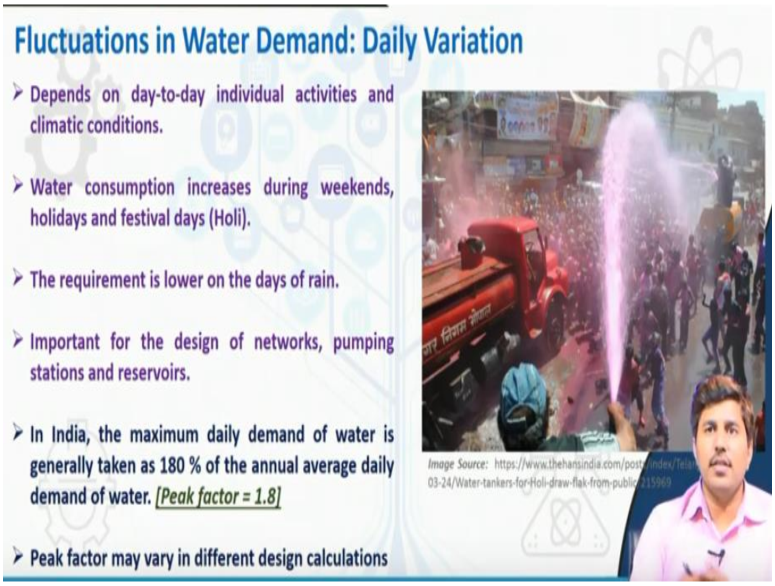
Whereas during winters the water demand is about 20% lower than the annual average because less water is needed at the domestic uses. At many places people do not even take bath on a day to day basis during the winters. So then the water requirement will obviously be lower in certain these kind of scenarios. During rainy season the outdoor demand for water, gardening etc. is very less.

So that is what happens from season to season or from month to month when we see these variations. But this is again, location is specific. It is not that same kind of variation is expected everywhere like in some high economic countries for example in Australia, the domestic demand of water in winter is higher than that in the summer. That is because in winter when you need hot water where you have facility of kind of hot water coming in your bathrooms, bathtubs, those places.

So in kind of order to get the normal temperature water you end up opening tap for some time then it comes and you try to mix cold water level it and make it comfortable for your bathing purpose. Similarly for cooking purpose, so this like combination and these things has kind of in a study it has been shown that in fact their demand in winter becomes higher than the demand in the summer, okay.

So that is about the impact of the kind of society or kind of the practices being used for living.

(Refer Slide Time: 19:27)



Then when we talk about the daily variation, again, it depends on day to day individual activities, okay and to some extent climatic condition. So we are not talking about here monthly variations or seasonal variations. Even if we see a month in summer, okay it is not that the requirement is going to be in a month of May it is not that the requirement on all days are going to be the same.

Or in month of January or February, any particular month it is not that requirement on all days is going to be the same. It is seen that water consumption during weekends, holidays, and festival days is more as compared to the water consumption on the regular business days. So in business days people like going to the office, schools all those so the requirement, household requirement of water reduces whereas on Saturdays, Sundays, weekends, festivals people more on the home.

Further, specifically during the festival seasons, there might be lot of cooking, lot of other activities needing water. So for say in India, if you see the highest water consumption, it is probably on a day when the festival Holi is celebrated, okay, because lot of water is used in kind of producing wet colors, coloring people and then getting those colors cleaned up.

So that way, probably the highest water consumption if we see in the year it would be on a Holi festival day. So it is much more as opposed to the other days in the same month. Holi typically falls in the month of March. So if you see the consumption, average consumption of water in a month of March, you will see that Holi probably have more than double or triple the average consumption on the other days.

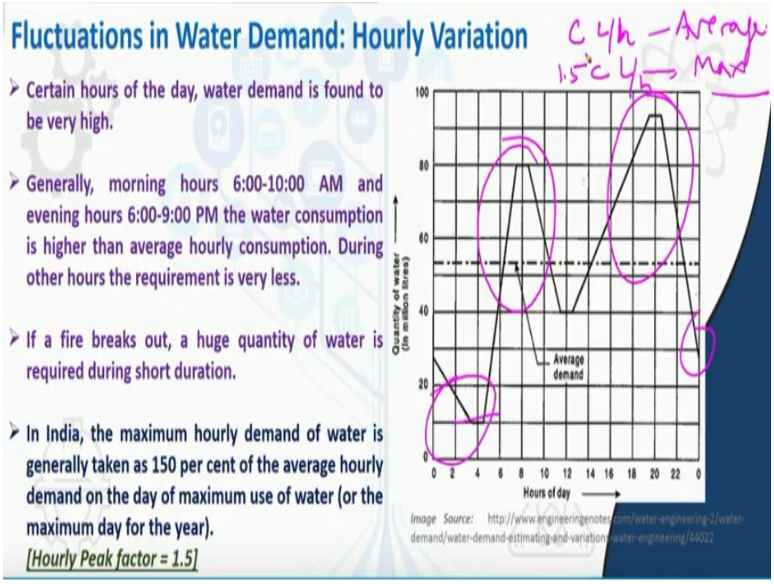
The requirement would be lower on the days of rain in a season. So that variation is also there. This is important for design of network, pumping stations, and reservoir because otherwise if you have a setup, which can perform say x amount of water on an average basis, if you do not consider this daily variation when your requirement on a festival or on a weekend or let us say on such festival day Holi day, it becomes 3x so your system will not be able to meet the demand, it will not be able to survive.

So that kind of issues might actually come and in order to cater that generally a peak factor is assigned to kind of elevate the demand. So the maximum daily demand of water, which considers the daily variation as well as seasonal variation is taken as 180 percent of the annual average daily demand. So basically using a peak factor of 1.8 okay.

So if your demand is 10 if your average daily demand is 10 million litres per day from a community or city, you have to consider the maximum daily demand could be up to 18 million litres per day which is 180 percent of the average value which is 10 okay. So you multiply 10 with 1.8 and you get a number of 18. So it could be 18 million litres per day for an example. And this kind of peak factors is taken in the design.

Now this peak factor like is recommended by the some agencies in India CPHEEO Indian standards, but it is not a universal number okay. The peak factor also may vary in the different design calculations. So someone might actually consider a factor of safety of two. So may take a peak factor of two like instead of 18 million he can consider a maximum daily demand of 20 million litres in that example.

(Refer Slide Time: 23:21)



So that like the peak factor can also vary that way. That is about the variation on a day to day basis which can give us the maximum daily demand, but even in a day, we often see hourly variations, okay. Means certain hours of the day water demand is found to be very high while certain other hours of the day the water demand will be very less.

And this is obvious generally morning hours when people take bath and those kind of like cooking, bathing and these activities. So we see the water consumption is higher than the average hourly consumption. Similarly in the evening when again, cooking, bathing and those kind of water consumption comes up. So again the water consumption is higher when we compare it with the average hourly consumption.

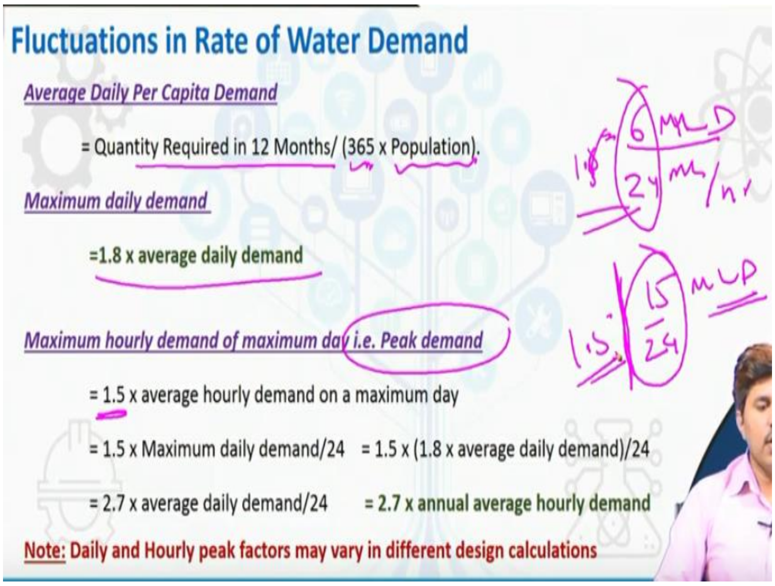
In the nights the water consumption is the least. So around say 3, 4 am nobody uses water in the house. People are actually sleeping. No cooking no other activity. So almost like very little or nil consumption of water. So that way, the water consumption varies within the day.

And for that purpose, the maximum hourly demand of water is generally taken as 150 percent of the average hourly demand on a day of maximum use of water or the maximum day of the year. So the maximum day is separate thing, but generally on any day, if on a particular day, say my water consumption is C so C is the average amount, say C liters per hour is my consumption okay.

So the maximum consumption, this is a average consumption. So the maximum consumption would be 1.5 C on that particular day. So this is going to be the maximum rate at which water will be needed, so this much litres per hour. So that way I can get the maximum demand, okay. So this is for accounting the hourly variations.

So hourly variation, we earlier discussed that we can use a daily scale peak factor which was 1.8 okay and for hourly scale variation we can use a peak factor of 1.5. Again the hourly peak factor also varies like daily peak factor. So this 1.5 is number recommended from the CPHEEO okay or is typically taken for designing the supply systems in India.

(Refer Slide Time: 26:00)



But it is not a universal number. The peak factors for hourly variation is also different in at different places. So with these peak factors, if we want to kind of see the fluctuations in the rate of the demand or if we try to estimate the demand, so what we see that the average per capita demand as we were just discussing, the average per capita demand can be taken as the quantity required in 12 months when we divide that with the number of days and the population, okay.

So we get the average per capita demand, but designing a system at average per capita demand is not advisable at all, because it will not able to, it will not be able to survive when the demand is higher. So for that purpose, we need to see on a daily scale what is the demand. So the maximum daily demand is 1.8 times of the average daily demand as we discussed earlier.

And maximum hourly demand which is actually considered as a peak demand for flow purpose specifically is considered as 1.5. So peaking factor, hourly peak factor is 1.5. So we take 1.5 into the average hourly demand on a maximum day, okay. Why we take on a maximum day because let us say there is going to be hourly variation on all days in the year okay.

It is not that there would be days when you continuously for 24 hours you need same amount of water okay. So hourly variations are expected on all days of the year and this hourly variation will be there when the demand is maximum also. So like on a day, when let us say on a winter day when you are having say requirement of 6 million litres water per day, okay.

So the 6 million litres water per day means per hour 6 by 24 million litres water per hour somebody needs okay. So this 6 by 24 number that you need in one hour is not that you will be needing for the entire 24 hours, okay. Again here is also there would be variations. Your system should be able to meet those variations and maximum demand could be 1.5 times of this number.

Similarly, when there is a like maximum daily demand, say in a summer day or in a festival day or whatsoever, so let us say instead of 6 you need 15 million litres of water on that particular day. So average hourly demand is going to be 15 by 24 on that particular day, and that day also it is not that you will be needing water continuously.

So that they also like we were just giving an example of a festival of Holi, so festival of Holi also the water requirement is much higher when the colors are played in the forenoon period and not in the afternoon. So afternoon water requirement may be higher as compared to the other days, but still not that much. So the maximum flow needed is during the morning hours.

And for that purpose you will have to use the factor here as well. So the point is that 1.5 factor which is usually taken for design purpose is taken on a maximum day. So maximum daily demand means, this is hourly demand, so average hourly demand on a maximum day, which can be estimated by the maximum daily demand by 24. And maximum daily demand is 1.8 times of the average daily demand.

So this becomes 1.8 times of the average daily demand by 24. And it eventually turns out to be 2.7. If we multiply these two peak factors, we get 2.7 into average daily demand by 24 which is actually the average hourly demand on an annual basis. So in order to get a peak demand or peak hourly demand, we can estimate the annual average hourly demand and directly multiply that with 2.7.

Or again, this peak factors vary for daily and hourly peak factors as well as this total peak factor also vary in the different design calculations. So 2.7 is one number. People may take 4, people may take 3. So different agencies also guide different numbers. But generally in India, this is what we adopt. In other places, most places in fact, it would be either 3 or 4 or that kind of number.

So that gives us the average like once we get the average annual hourly demand and multiply with this number, we get the peak demand or maximum hourly demand that will be needed in a water distribution system. And this demands helps in designing because our supply system, whatever supply system we propose should be able to meet this demand okay in a hourly basis.

So we conclude this discussion here on the fluctuations in the water demand and in next class we will see how the demand is estimated and more so ever what is the concept of design period and design population which is used for the estimation of the water demand. So see you in the next class, thank you for joining.