Urban Utilities Planning: Water Supply, Sanitation and Drainage
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Module - 05
Water supply Distribution system and Plans
Lecture - 24
Pipes, Joints, Meters and SCADA Systems

Welcome back. In lecture 24, we will talk about Pipes, Joints, Meters and SCADA systems.

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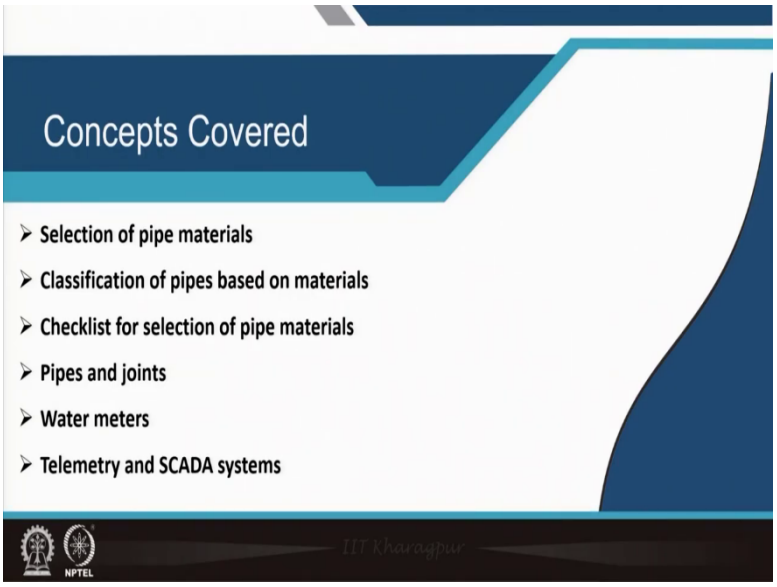

The different concepts that we will cover include selection of pipe materials, classification of pipes based on materials, checklist for selection of pipe materials, pipes different kinds of pipes and joints, water meters, and then we will talk about telemetry and SCADA systems.

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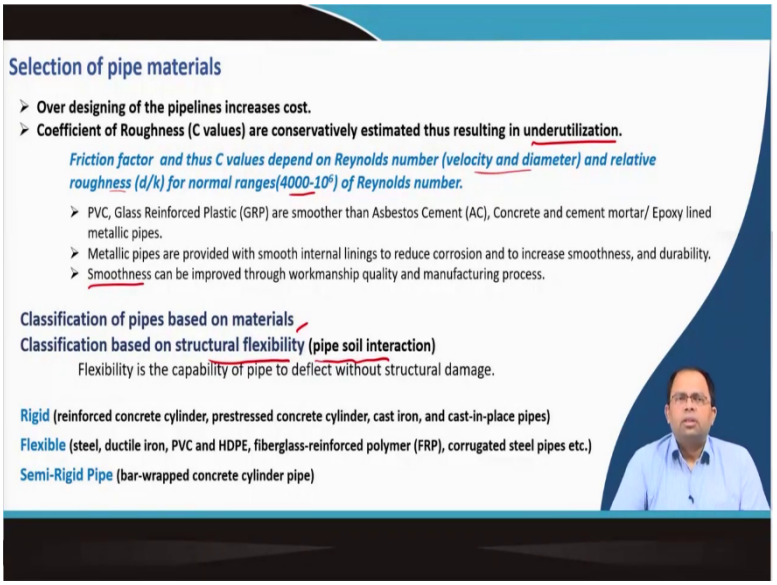

Selection of pipe materials

So, from our earlier lectures, we have already discussed that the selection of pipe material is based on many factors. And the selection of pipe materials has to be carefully done as over designing of pipelines increases the cost. The coefficient of roughness or the C values that are conservatively estimated results in underutilization. Then we end up designing infrastructure which is not required or pipelines which are over designed.

So, friction factor and thus C values depends on Reynolds number which we have learned earlier which depends again on velocity, diameter, and viscosity, and density of liquid and so on. So, particularly, velocity and diameter are important for pipelines. And relative roughness for normal ranges of Reynold number that is 4000 and up.

So, these are the ones which primarily determines the kind of pipe materials to be used. The different materials are PVC, glass reinforced plastic, GRP, asbestos cement concrete, and cement mortar epoxy lined metallic pipes. Metallic pipes are provided with smooth internal linings to reduce corrosion and to increase smoothness, and durability. They are sometimes lined with concrete which actually increases the smoothness of those particular pipes. And smoothness can be improved through workmanship quality and manufacturing process. So, smoothness or roughness is very important for pipe selection. So, pipes could be classified

based on the materials or it could be classified based on their structural flexibility. Structural flexibility is important considering the interaction between the soil and the pipeline.

Flexibility is the capability of the pipe to deflect without structural damage. So, there are 3 kinds of pipelines, one is rigid, one is flexible and then there are semi-rigid pipes. Rigid pipelines are made of RCC, reinforced concrete cylinders, pre-stress concrete cylinders, cast iron, cast in place pipes. Whereas, flexible pipes are steel pipes, ductile iron, PVC, HDPE, glass-reinforced polymer, all these fiberglass reinforced polymer, corrugated steel pipes. And then there are semi rigid pipes as well. So, either we can classify based on the rigidity or we can classify based on the materials.

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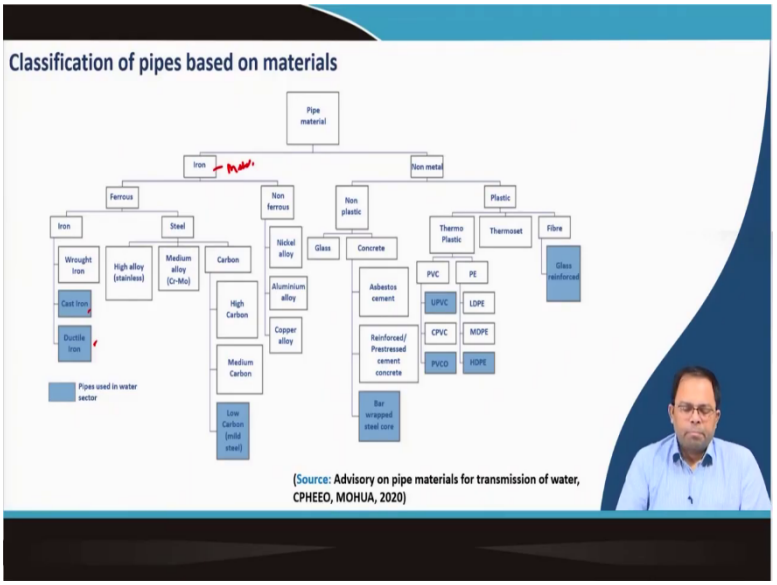

Classification of pipes based on materials

There are different kind of materials to choose from. It can be metallic or non-metallic, ferrous or non-ferrous, alloys, plastics and many more as shown in Figure 1. So, we need to understand what is the pros and cons, and what are the ratings of the different kinds of pipes, check if it matches for thickness, size, test pressure such as internal pressure, external pressure, and so on. So, based on that we will choose the pipes.

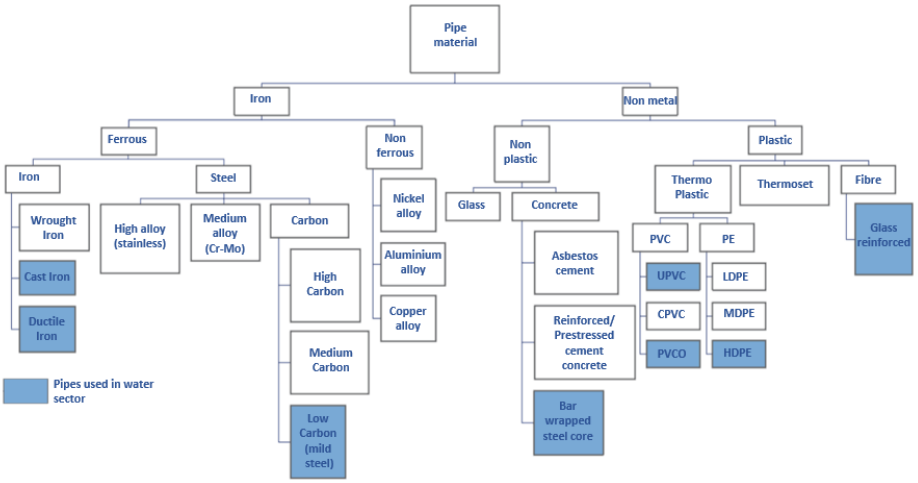

Figure 1 Classification of pipes based on materials

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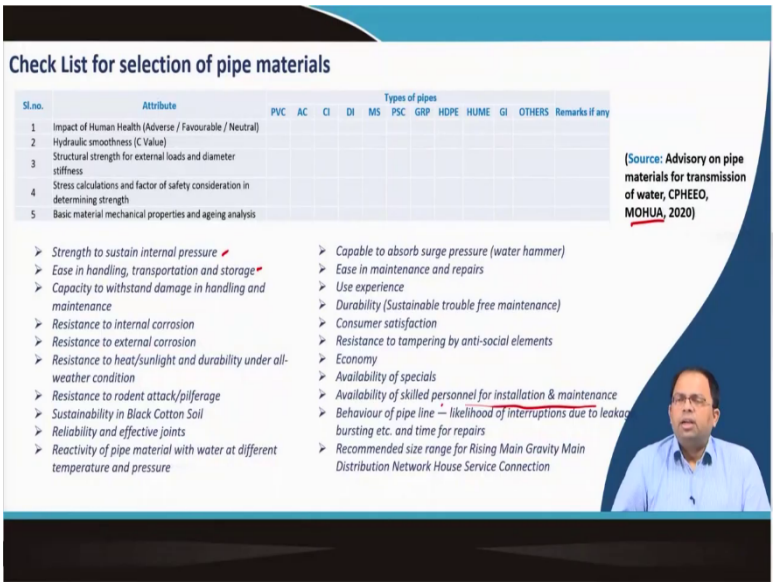

Checklist for selection of pipe materials

Decision to select pipe materials depend on a number of things. Apart from the diameter, material, roughness, there are government mandated criterial to be met. Government of India, on its advisory on materials for transmission of water by CPHEEO, and ministry of housing and urban affairs, have listed these different points which has to be considered when we choose a pipe material. So, you can understand the importance of determination of pipe material when we design a water supply network.

So, first of all we have to look into impact on human health of this particular material, hydraulic smoothness, structural strength of external loads and diameter stiffness, stress calculation and factor of safety considering consideration strength, basic material, mechanical properties and ageing analysis. Then, strain to sustain internal pressure, ease in handling transportation and storage which are site specific. That means, certain pipes are suitable for certain areas because there may not be space to store them or there may be issues with transporting them. So, you cannot use very heavy pipes and so on. Capacity to withstand damage in handling and maintenance, resistance to internal corrosion, resistance to external corrosion, resistance to rodent attack, reliability effectiveness of joints. Use experience, ease in maintenance and repairs, then durability, consumer satisfaction, economy, resistance to tampering by social elements, then availability of skilled personnel for installation and maintenance are some of the factors to be considered.

So, not all can be considered for in every case, but wherever possible we will look into all the factors and then make a decision on which pipe to use or which material to choose from.

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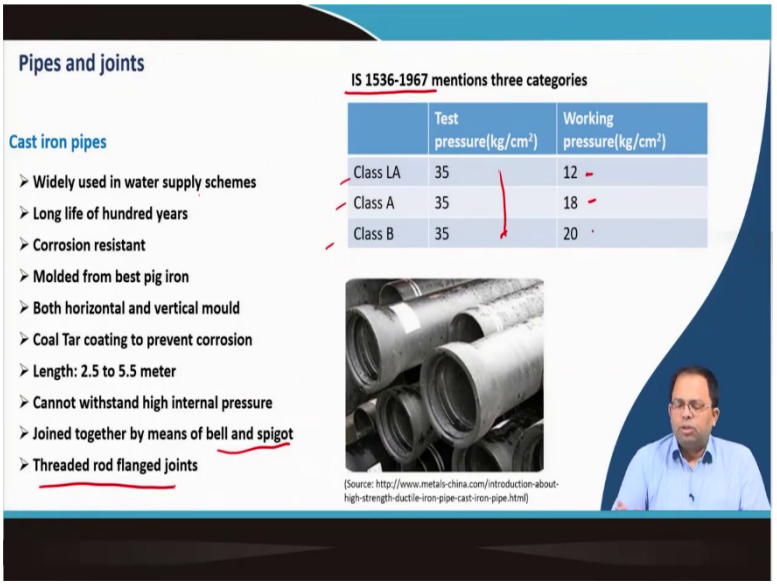

Pipes and joints

Now, let us look at the different kinds of common pipes and joints. Cast iron pipes and their classifications are specified in the IS 1536 to 1967 which shows the different categories of

pipes. It basically has 3 classes of pipes, class 3A, class A and class B. Each class can take care of different pressure, like working pressure for these 3 classes are 12, 18, 20, whereas, test pressure is all same. That means for a small period of time it can all withstand 35 kg per centimeter square of pressure, but for a longer period ratings that these are different for each class.

Cast iron pipes are very widely used in water supply schemes. These are very common as they have long life, are corrosion resistant and are molded from pig iron. And the molds are both horizontal and vertical. A coal tar coating is provided to prevent corrosion. Typical lengths are around 2.5 to 5.5 meter.

They cannot withstand high internal pressure, but they can withstand outside external pressure. And they are joined using bell and spigot joints and or threaded and flanged joints.

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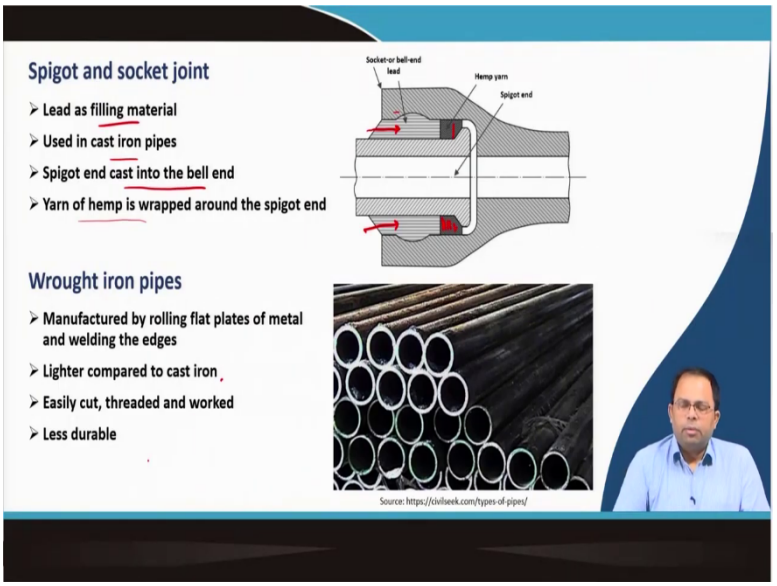

Spigot and socket joint

Hemp or yarn is wrapped around the spigot end and it is cast into the bell end. So, this is how we actually connect the different pipelines. Lead is used as a filling material. Mostly used for cast iron pipes, spigot end cast into the bell end, and yarn of hemp is wrapped around this spigot end.

So, similar to cast iron pipes, we also have got wrought iron pipes which are almost similar, but these are manufactured by rolling flat plates of metal and welding the edges. So, instead of the previous kind of cast iron pipes where it was put into molds, here we actually have flat sheets which is actually rolled and then welded up. And these are lighter compared to cast iron. They can be easily cut, threaded, and worked, but they are also less durable.

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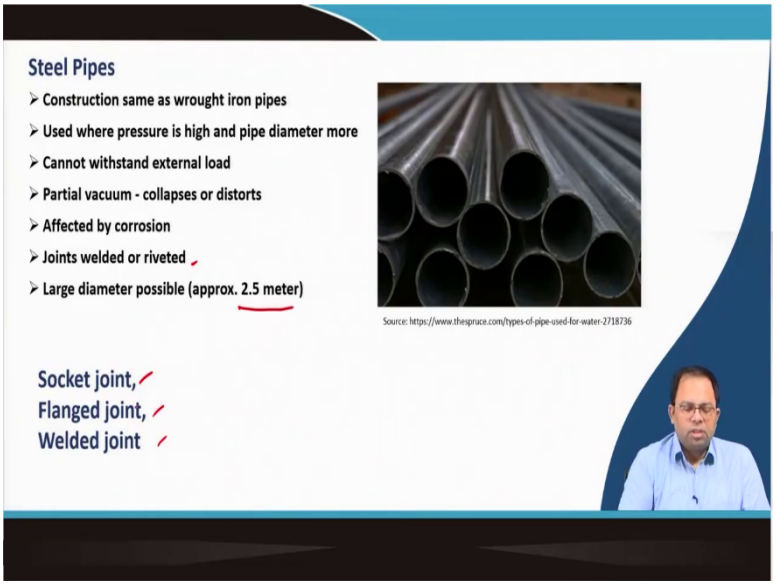

Steel pipes

The construction of steel pipes is similar to wrought iron pipes. And this is used where internal pressure is high and pipe diameter is required is more. These pipes cannot take high external loads, so they are not suitable for taking load from above. We can make flat sheets, roll it, and weld it.

And in case a partial vacuum is created, sometime these kind of pipe collapses. And they are affected by corrosion to some extent. The joints are either welded or riveted joints and we are able to have large diameter pipes. 2.5-meter diameter pipelines are even possible.

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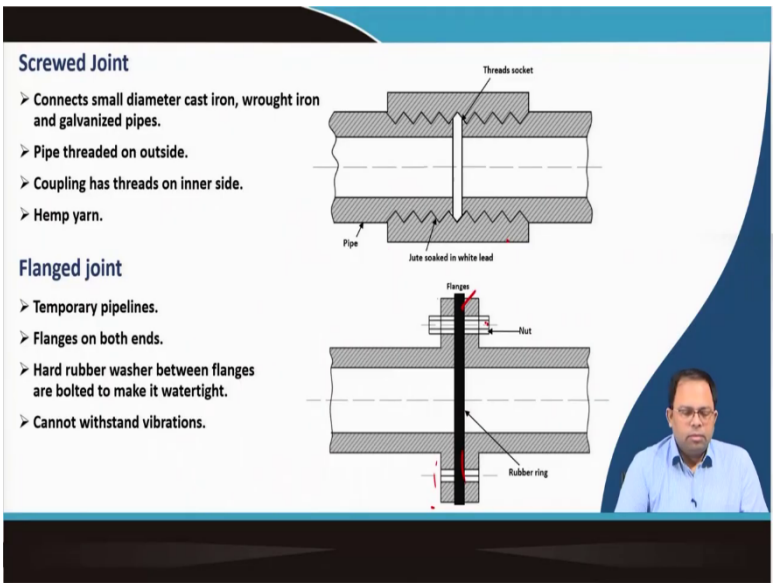

Flanged joints

In flanged joints, both pipes have got a sort of collar. And then there is a screw which connects these two pipes, and in between we give a washer, so that it becomes watertight. So, but as you can understand that it depends on the number of screws that are fitted and in case there is vibration, the screws can come loose or there may be gaps which may form over there. So, that is why these pipes are good for temporary cases or in cases where there is absolutely no vibration.

Screwed joints

In case of screwed joints, we have a separate piece which connects small diameter cast iron, wrought iron, and galvanized pipes. And the pipes are threaded on the outside and thise coupling has got threads on the inside and we just rotate the pipes and fit them into the coupling from both ends. And we can also use hemp and yarn in the gaps so that this gap becomes watertight. So, this is how screwed joints and flanged joints are done.

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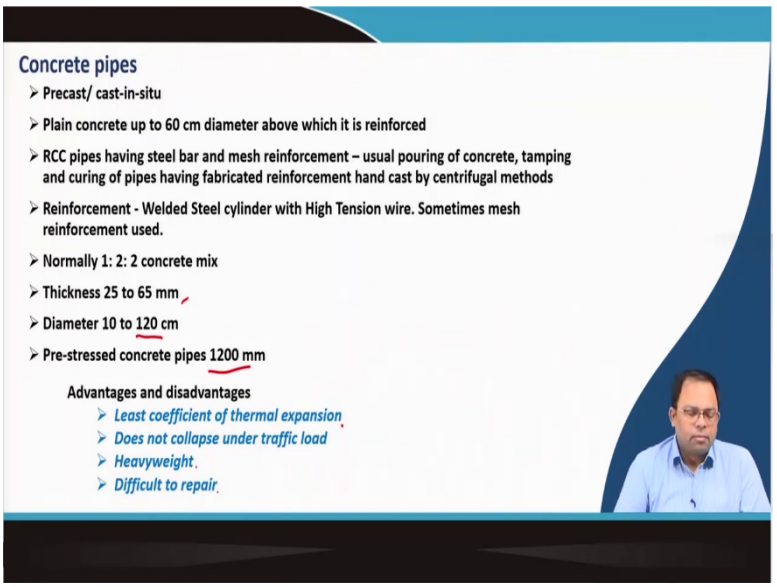

Concrete pipes

The concrete pipes are mostly precast or it could be cast in situ, but precast is usually preferred. They can be plain concrete or reinforced concrete pipe. Plain concrete pipe up to a diameter of 60 centimeter or 2 feet and beyond that we have to go for reinforcement. Reinforcement can be of different kind. It could be steel bars with mesh reinforcement. Then concrete is poured, and then tamping and curing is done. We can cast using centrifugal methods. It could also be a welded steel cylinder with high tension wire and also with mesh reinforcement. And the concrete mix is usually 1: 2: 2. Thickness of this kind of pipe is 25 to 65 mm and diameter up to 120 cm. So concrete pipe diameter can start from 10 cm centimeters and pre-stressed pipes can go up to a 1200 millimeter or 120 centimeters.

These kinds of pipes have a lot of advantages. They are able to take a lot of external load because these are pretty thick. These pipes has the least coefficient of thermal expansion. So, thermal expansion is not that big an issue. It does not collapse under traffic load, but the problem is these are of heavy weight. These need to be transported using lorries which is difficult in many places and these are difficult to repair as well.

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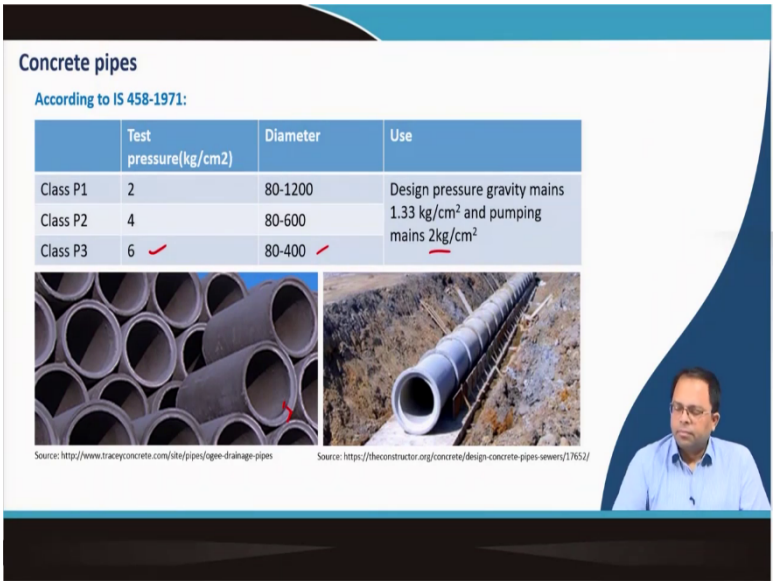

So, there are again 3 classes of pipe as given in IS 458-1971, class P1, P2 and P3. So, test pressure is around 2 kg per centimeter square or 4 or 6 kg per centimeter square and design pressure is 1.33 kg per centimeter square, and for gravity mains and for pumping mains around 2 kg per centimeter square.

So, diameter supported is 80 to 1200 for P1, 80 to 600 for P2 and for P3 80 to 400. So higher the test pressure, lesser is the diameter. If the internal pressure is high it is better to opt for steel pipes and other pipes.

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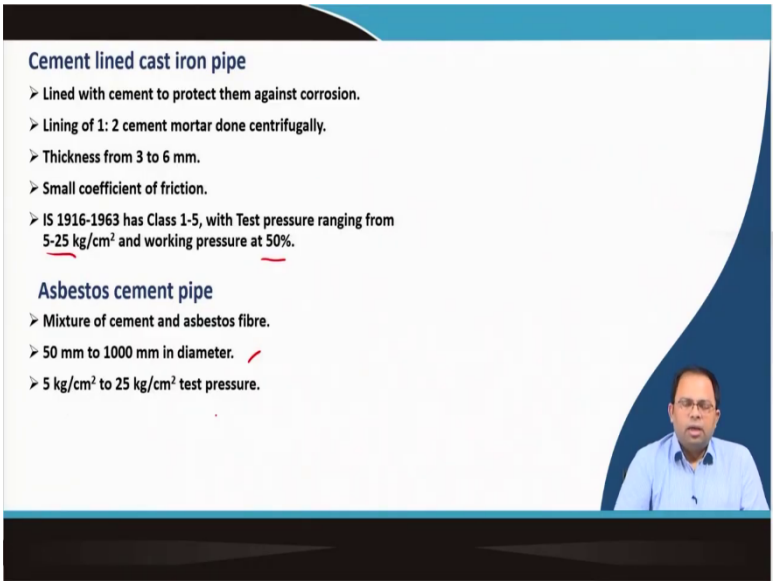

Cement lined cast iron pipes

If we want to get the benefit of both cast iron pipe and a cement pipe, we use cement lined cast iron pipes which actually increases the smoothness of that particular cast iron pipe and also increases its longevity by reducing corrosion. The lining is made of 1: 2 cement mortar, and it is done using centrifugal methods. And thickness is around 3 to 6 mm and friction coefficient is small. The IS 1916-1963 has 5 classes, classes 1 to 5, and test pressure ranging from 5 to 25 kg per centimeter square and working pressure at 50 percent of that; that means, 2 to 12 kg per centimeter square of working pressure. Similarly, we have got asbestos cement pipe, it is a mixture of cement and asbestos fiber 50 to 1000 mm in diameter, 5 kg to 25 kg centimeter square of test pressure.

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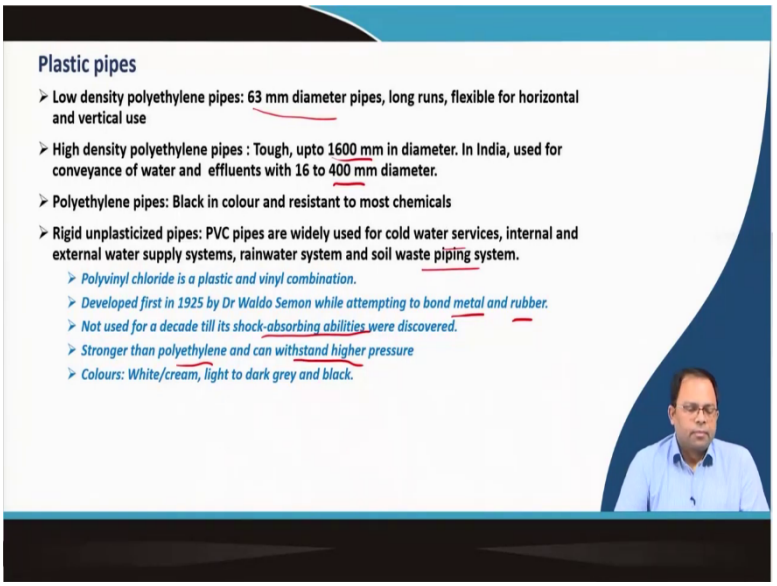

Plastic pipes

Finally, the most common pipes that we find today are the plastic pipes. There are different kinds of plastics such as low-density polyethylene, high-density polyethylene, polyethylene pipes, just simple pipes and rigid unplasticized pipes. Low density polyethylene pipes up to diameters of 63 mm diameter can be flexible and can be used vertically as well. High density polyethylene pipes could be of larger diameter 16 up to 1600 millimeter. But in India we find

only until 400 mm in diameter. Polyethylene pipes are also used. Then, there are PVC pipes which are used for cold water services, internal, external water supply systems, rainwater systems, and soil water piping systems.

There is a history behind the development of PVC pipes. It was initially developed in 1925 by combining plastic and vinyl by Doctor Waldo Semon, when he was attempting to bond metal and rubber. And then, the shock absorbing abilities were discovered for this kind of pipe and they became really popular. These are stronger than polyethylene and can withstand higher pressure and we can find them in usually in white and cream, or light to dark gray colors and even in black color.

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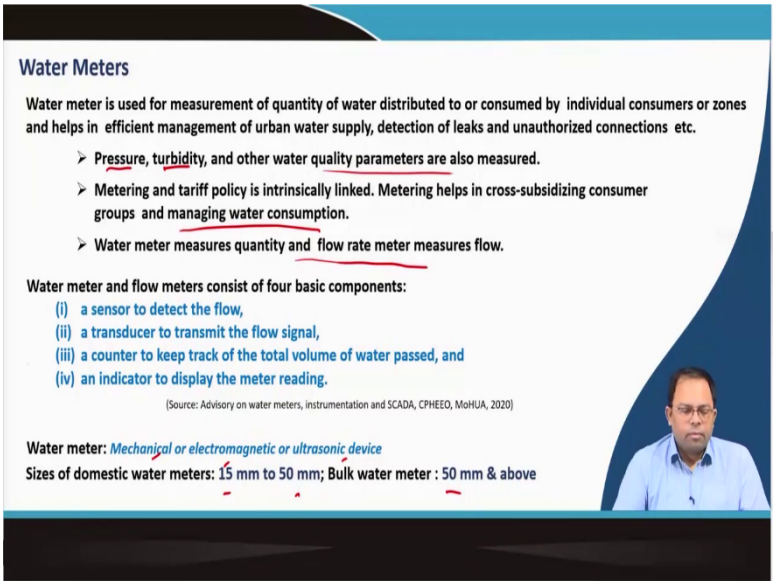

Water meters

Next, we will talk about water meters. It is used for measurement of quantity of water distributed or consumed by individual consumers or it could be for zones, and this helps in efficient management of urban water supply, detection of leaks and unauthorized connections. The prime purpose of water meters, both at the zone level and the individual level, is to detect the amount of water that is being consumed.

So, water meters are nowadays changing, from simple water meters to smart water meters. Along with the flow or the quantity of water, they can measure pressure of water, turbidity of

water and some other parameters as well. For this purpose, some of these sensors are inbuilt into the water meter.

Metering and tariff policies are intrinsically linked. Metering helps us to know exactly who is drawing how much water and that helps us to design the tariffs, designing the cross subsidies from one consumer group to another.

So, for managing water consumption, to reduce wastage, to reduce unaccounted water, to design proper tariff policies by a utility provider, we need to have water meters. Water meters are absolutely essential, even though they may reduce a little bit of pressure in the pipeline, but still their benefits outweigh their shortcomings.

A water meter and flow meter consist of 4 basic components, a sensor that detects the flow, a transducer to transmit the flow signal, a counter to keep track of the total volume of water passed and an indicator to display the meter readings. So, water meter could be a mechanical device, an electromagnetic device or an ultrasonic device.

These meters are basically of different sizes, one is 15 mm to 50 mm for individual domestic water supplies, and 50 mm and above for bulk water meters.

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Next we will discuss the different types of meters. The first one is a mechanical meter. There are two kinds of mechanical meter, one is a volumetric one and the other is an inferential one. The volumetric one directly measures the volume of flow of water. These are basically the rotary piston meters. There is a rotary piston inside, so positive displacement happens inside and a rotating cylindrical piston measures the packets of water, how many packets of water is actually going through that. And from each packet we know the volume of water in each packet and we can determine the total quantum of water that is being passing. So, this is a mechanical system which is utilized to measure the flow.

Then, there are inferential meters which are of 3 kinds, one is a single jet meter, multijet meter and a Woltman meter. Instead of measuring the quantity or the volume of water, it measures the flow rate and the velocity of water. Based on velocity and flow rate it can determine what amount of water is passed by multiplying with the diameter of the pipeline. These kind of meters have got an impeller with radial veins which is also called a fan wheel and there would be single flow of water inside on this fan wheel which makes it rotate. And when it rotates, based on the speed of rotation, we can determine what is the speed of flow of water, which could either be a single jet of water or there could be multiple jets of water which rotates. Accordingly, you get single jet meter and multijet meter.

Woltman meter measures an impeller with helical veins like a fan or a boats propeller which is a little different from the other two meters.

Other than mechanical meters, we have electromagnetic meters and the domestic electromagnetic meters are DN 15 to DN 40, depending on the size and bulk electromagnetic meters starts from DN 50 to DN 300. Electromagnetic or magnetic field is created inside the pipe, and when water moves inside the pipe, it induces a voltage because it is moving through a magnetic field which could be detected by the electrodes in the body of the meter. This voltage generated by the flow of water is actually proportional to the flow velocity. Based on that flow velocity we can now determine the quantum of water present.

We have got ultrasonic water meters making use of sound waves. These are of two types: a transit time ultrasonic flow meter and a doppler ultrasonic flow meter. The sound waves whenever it moves in water, if it moves in the direction of water, it will move faster, if it

moves in the opposite direction of water it will become slower. And so, that time taken by ultrasonic sound wave to travel from one point to another is used to determine the speed of water. The Doppler ultrasonic flow meter measures changes in the frequency of a sound wave when it is reflected back from the moving object or moving water in this particular case.

So, these are the different types of meters that are used in pipelines or water supply pipelines. Meters are required for determining many things such as water consumption of the different socio-economic groups and the reason for the same. This can be then utilized to determine charges, requirement of cross-subsidy and so on.

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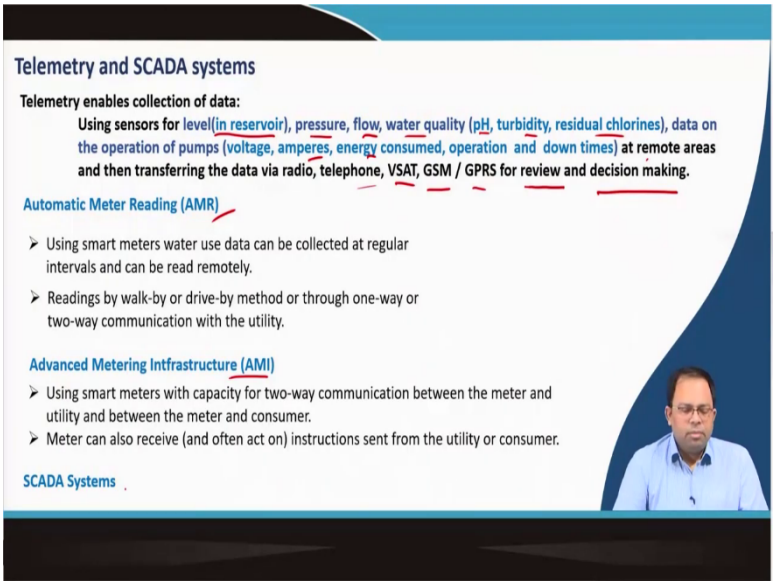

Telemetry and SCADA systems

Smart meters are the ones where we can collect automatic meter readings and at the same time, it would be able to transfer the data from that meter to outside. Or it could be two-way communication as well, in between the meter and the consumer, or the meter and the utility and so on.

Telemetry refers to the collection of data using sensors employed not only in the pipeline but also in water treatment plants, service reservoirs and so on. We put sensors in the water levels to understand the water levels in the reservoir. It is used to determine pressure, flow, water

quality, pressure and flow in pipelines, inside a water treatment plant, water quality inside pipelines in terms of its pH, turbidity, residual chlorine and so on.

It also collects data on the operation of pump such as voltage and ampere requirement, energy consumption, operation and downtimes for pumps based on which we can improve the efficiency of utilization of the pumps. And once all this data is being sensed then this data needs to be transmitted, and in case of remotes areas where people are not stationed like automatic pumping stations and automatic treatment units, then the data is transferred either via radio, telephone, VSAT, GSM, GPRS and different kind of IOT systems. This data is transferred to the headquarters for review and decision making. So, this is where the data is stored in a database and then it is analyzed to determine the trends, kind of leakages and so on. We can thus determine the water use data from meter at certain intervals or we can remotely read it.

Besides, we do not need to dig up a particular pipeline or if it is inside a particular of chamber, we do not need to open it up. We can just pass by and have a handheld device and there could be two-way communication between this device and the meter and the data could be downloaded from that particular meter. So, this is the automatic meter reading system.

And similarly, we have advanced metering infrastructure, AMI, where two-way communication is possible between the smart meter and the utility or between the meter and the consumer. That means, a consumer can give an input to that particular meter such as stop the connection, stop the flow, or hold the flow for say two months because he would be out of the house and or for the utility to let you know about change in a certain rate or some other instructions. This be done via two-way communication between the meter as well as the utility and the consumer. So, that is what advanced metering infrastructure is all about. So, AMR and AMI systems are gradually being deployed everywhere.

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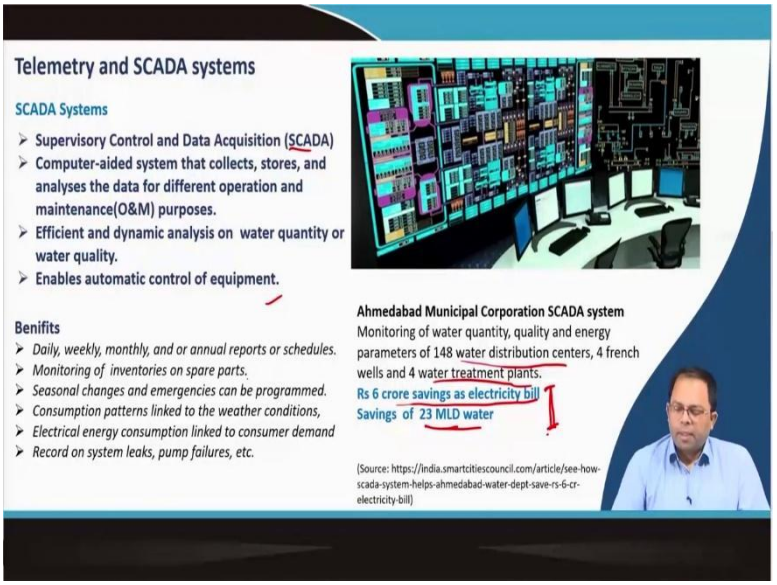

Then we have the SCADA system. SCADA refers to supervisory control and data acquisition. It is a system where all the data that we are collecting from the sensors are stored and this data is analyzed so that we can streamline our operation and make it more efficient. We can carry out lot of analysis on the water quantity, water quality, the trends and accordingly we can adjust our operation which reduces the cost of operation. It through this kind of system we can automate the control of equipment as well. So, similar to communicating with this meter, we can also communicate with pump equipment and other things which are also present in the system.

So, the benefits of a SCADA system are multifold. We get reports out of this system which helps in the process of decision making, helps understand what kind of inventories we hold or require, what kind of expected failures or what parts should be replaced. We get to know about the different kind of seasonal changes and emergencies and what to do in those cases, what kind of systems to run which could then be programmed. Consumption patterns linked to weather conditions like rainfall, and accordingly we can adjust treatment rates and so on. Electricity energy consumptions, system leaks and pumps failures can also be monitored.

Gradually many municipalities in India are now installing this kind of SCADA systems and advanced meter systems. In Ahmadabad municipal corporation, they have installed the SCADA system, and they monitor water quantity, quality, and energy parameters in 148 water distribution centers, in 4 French wells and 4 water treatment plants. They have more or less automated the entire process by gathering data from all the different processes and they were able to save around 6 crore rupees as electricity bill and also 23 MLD of water by reducing wastage. The benefits definitely outweigh the compilations for its installation costs and usage including training of staff.

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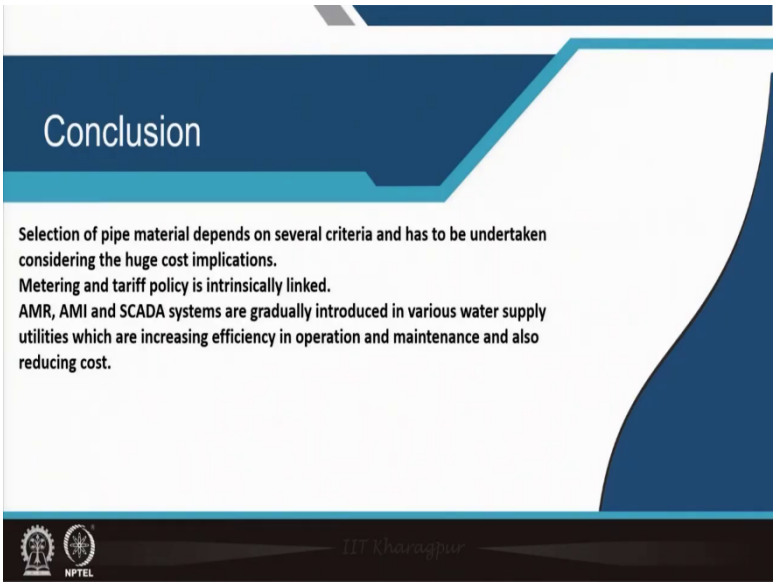

Conclusion

So, to conclude selection of pipe materials depend on several criteria, and has to be undertaken considering the huge cost implications. Metering and tariff policy is intrinsically linked. So, meters are extremely important to be installed in water supply distribution network. AMR, AMI and SCADA systems are generally introduced in various water supply utilities which are increasing efficiency in operation and maintenance and also reducing cost.

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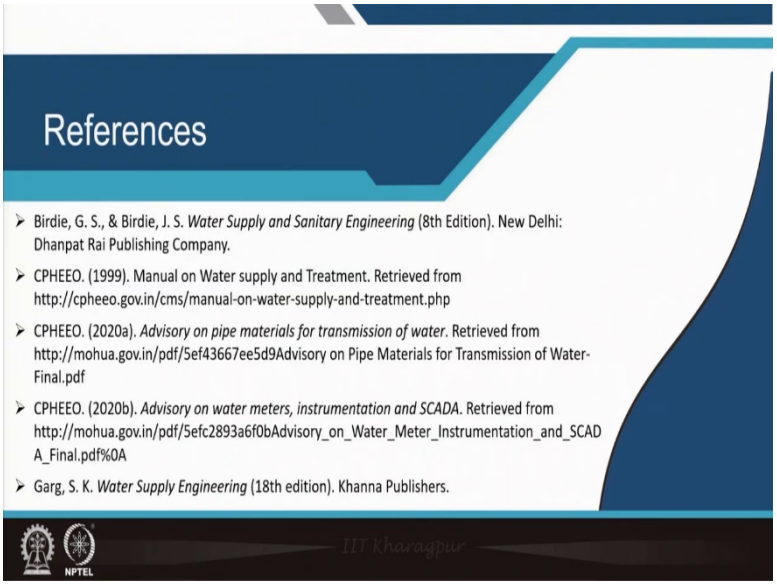

So, these are the references you can study.

Thank you.