Basic Construction Material
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Module No # 08
Lecture No # 41
Metals 5- Part 2

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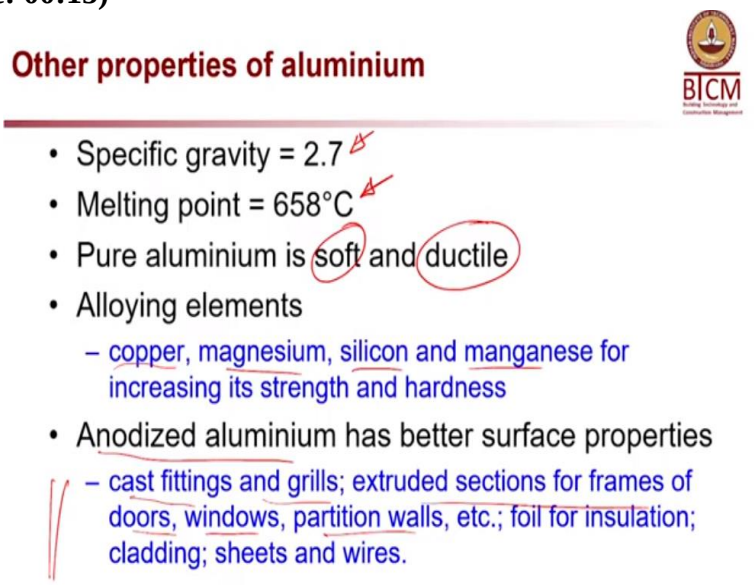

Other properties specific gravity is 2.7 and melting point is 658 degrees Celsius pure aluminum is very soft and ductile. So that is why it is not always preferred for structural applications; what are the methods of aluminum alloying elements? Typically you put copper, magnesium, silicon, Manganese for increasing the strength and hardness. And another way to enhance the properties by anodizing the aluminum.

Which is used for cast fittings, grilles extruded sections for frame drawers, doors, windows, partition walls. So you can notice this all these are non-structural elements they are not part of the major beams and columns in a building.

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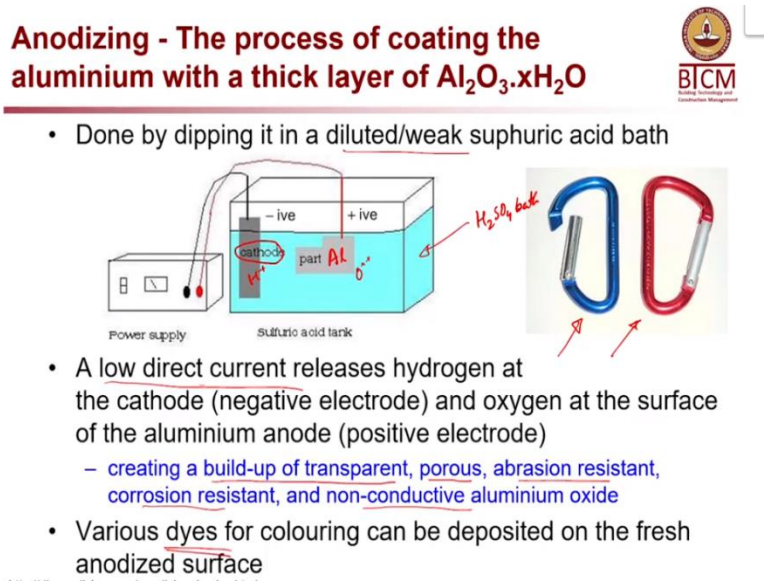

So I will show you some, how this anodizing is being done? What is this? This is a process of coating the aluminum with a thick layer of aluminum oxide. So it how is it done by dipping the aluminum in a diluted or weak sulphuric acid bath, What you see here is the sulfuric acid bath. H_2SO_4 bath then you, have this is aluminum, and this is a cathode here, and aluminum is the anode.

So a low direct current or low DC current has released the hydrogen at the cathode, and it releases the oxygen at the surface of the aluminum anode and which is the positive electrode. So what happens eventually is that the aluminum oxide is formed at the aluminum surface. Now creating a built-up of a transparent porous abrasion-resistant corrosion resistant and non-conductive aluminum oxide.

So there are so many properties for this aluminum oxide, which we call anodized aluminum. And to provide color, as you see on the right side, there is a key chain with the blue and red color that is achieved by using some dye. Colouring dyes or pigments can be deposited on the fresh anodized surface I will show you how it is done.

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So you can see here this is a yellow shaped you know you can see here this one this element it is a yellow color because they used a dye which has a yellow color. And this is you can see here it is a zinc bath at the bottom of that you can see here also there is a zinc bath into which this is dipped sorry not zinc bath I am sorry it is a sulfuric acid bath into which it is dipped. And then after that, it is cleaned, and all those processes you know this is essentially the cleaning process going on.

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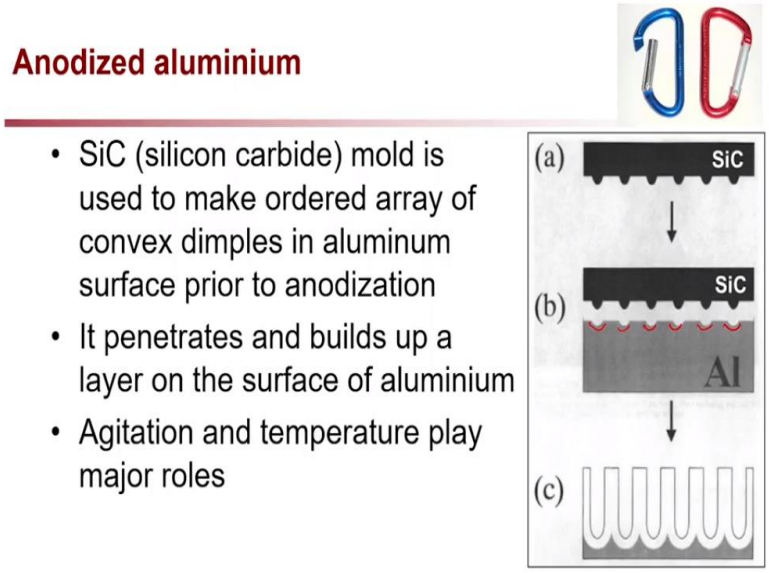

Now how the anodized aluminum is made, or how is it enhanced that it is ensured that there is a good resistance both in terms of hardness also. And then also we need some kind of pockets for the dyes to occupy the space so that it gives color to it. So what we do is first the process is you

take a silicon carbide the, you know mold the reason is it you have this indent I mean these protrusions.

When this is pressed against the aluminum plate, there will be indentations formed on this. So you are essentially making a uniform structure with indentations, and then you grow the aluminum oxide on that surface. So this is the aluminum oxide which is grown by applying current to it; this is that oxide layer the white thing, so you have this oxide layer formed.

Now then you have the how the mixing process or the movement of you know the dipping elements or the anodes in the solution or the fluid. The flow of this solution around this thing and the temperature of the solution play a key role in forming this oxide layers.

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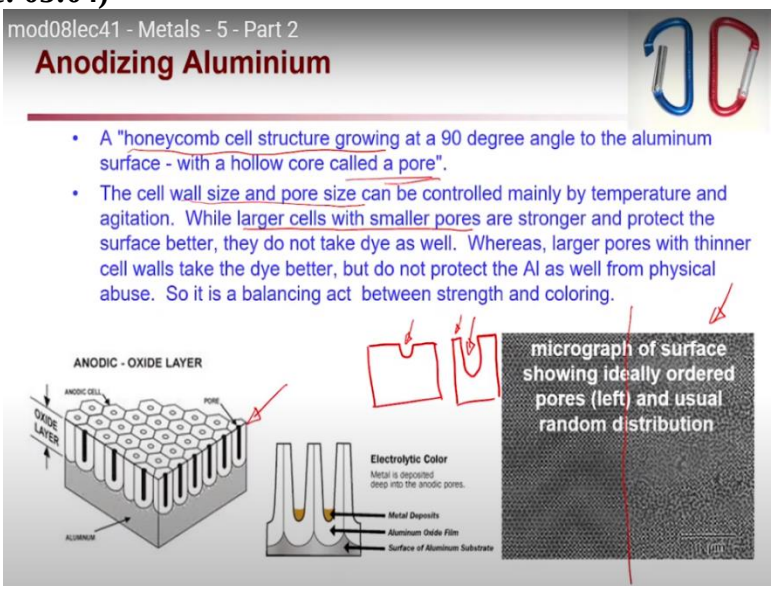

So eventually, what you get it you can look at the oxide layer or the U-shaped layer formed. It is a microscopic scale. And then inside that, you have metal deposits or which is giving you the color also. And then, in a somewhat 3D scale in a view, it will look something like this, so you have this U-shaped pocket. So honeycomb structure, you know similar very similar to a honeycomb cell structure with a whole core called a pore.

And in that pore, you will know to fill the coloring dye coloring pigments, etcetera. But now, the relationship between the cell wall size and the properties. So the cell wall size and pore size can be controlled mainly by changing the temperature and mixing the solution or agitation. Now, while large cells with small pores are stronger and protect the surface better, do not take the dye.

In other words, large cells, so let us say I am going with a cell like this. And so let us say I have a pore-like; this is 1 case assumed, and another case is small pore but large pore volume. So these are the 2 cases we are talking about large cells with small pores that is this case here are stronger and protect the surface better, but they do not take the dye as well means that there is no space for the diet to be occupied whereas the large pores with thinner cell walls. So, this is the thinner cell wall that means the pore size is larger.

And they will take the dye better but do not protect the aluminum and physical abuses. So you will have a lot of damage or abrasion those kinds of problems could be there so essentially when you talk about longevity etc. It is a balancing, and you have to adjust the size of the pore size and size of the cell wall thickness etc., have to be adjusted so that you get optimized properties.

On the bottom right, what you see is a micrograph of the surface anodized surface showing ideally, as you know, ordered pores on the left half. You can see here on the left half of the drawing, you have an ordered structure, whereas you have a random distribution on the right. So these are all manufacturing, you know, procedures or the anodizing procedures.

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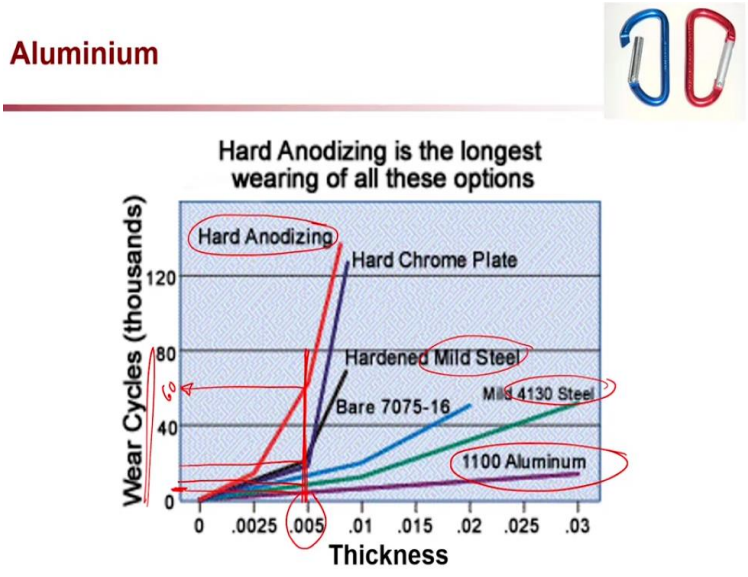

The advantage of doing this anodizing is that anodized aluminum is the one with the red curve here and another, typical aluminum1100. So the properties range of how it can change and mild

steel is here and hardened steel here so the hardness. So this property is where essentially looking at the wear cycles, so it looks at abrasion resistance or hardness.

You know how resistive, not hardness, necessarily how resistive the material is against abrasion, so it looks at wearing cycles. So as a function of the wearing cycle, what is the thickness so? If you look at the horizontal axis, let us say I am going to look at here let us say 0.005 let us take this point. At a thickness of 0.005, that much material, it takes how many are wearing cycles for that to lose.

So in the case of aluminum, almost nothing; this is where the aluminum you know it is right here, and then in case of mild steel, maybe this is here. In the case of hard and mild steel, you can see it is somewhere here, and in the case of hard-anodized aluminum, it is somewhere here. So that is the huge difference you can see. How many extra or additional like that is about 60 cycles were required to remove the thickness loss that is looking at.

So definitely, when you anodized use the anodized aluminum, you have a very excellent surface property. So the aluminum with anodization or anodized aluminum will have very good wear resistance or abrasion resistance I mean, it can be related to that also if not directly, and that means hardness is also very good.

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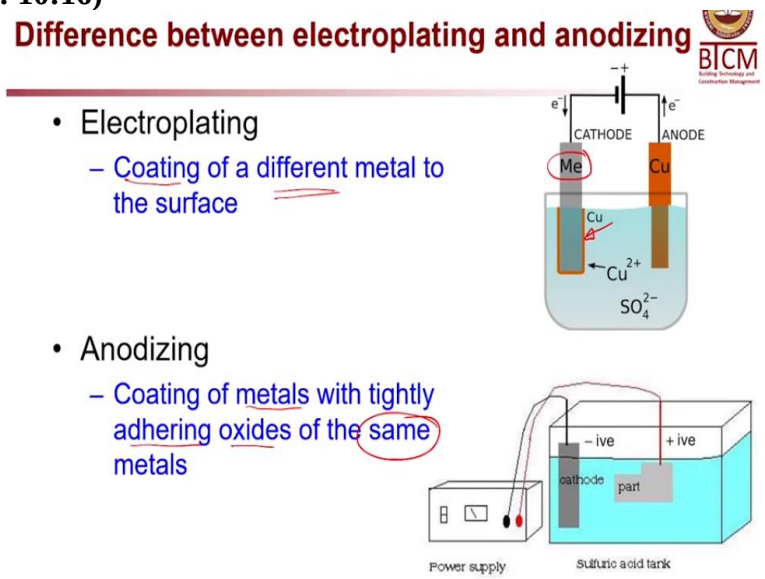

Let us look at the difference between this and electroplating; you might have heard about this in your earlier schooling. So let us see the difference between electroplating and anodizing what

electroplating is? Electroplating is essentially coating a different metal to the surface. So if this is on the top right, you can see if this is the metal you want to coat are in this particular example, copper is coated onto the metal that needs to be protected.

So any metal can be coated with copper; that is the way by which when we talk about electroplating, that means that. In the case of anodizing, what it means is? Coating; of the same oxide coating of metals with tightly adhering oxide of the same metal that is the difference. So in the case of electroplating, one metal is coated onto another metal. In the case of anodizing, a metal oxide is coated with that same metal, so this is the main difference.

And when you do this metal oxide being coating oxide coating, you get change the corrosion properties because it is electrical resistivity, etc. And then you also change you know that depends on the property of the oxide layer but essentially you, get a hard surface etcetera hard and corrosion-resistant surface.

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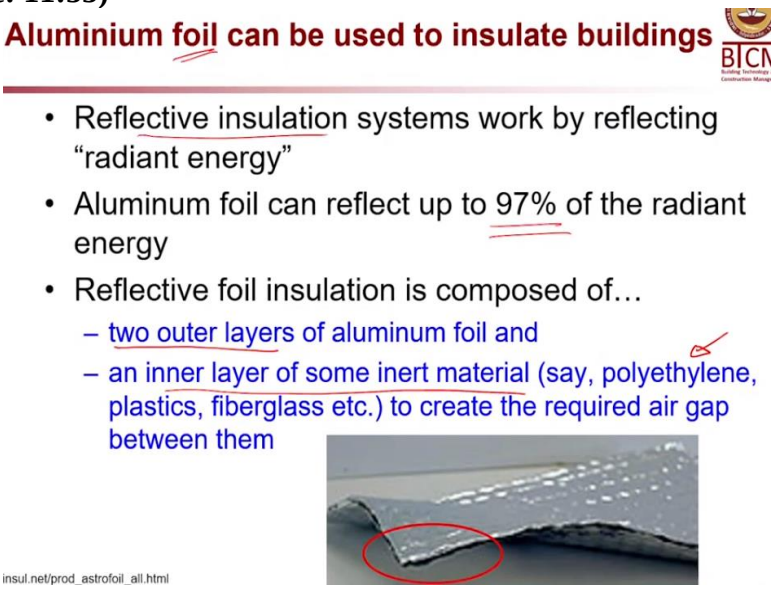

Where do we use aluminum? Aluminum foil can be used to insulate buildings even though not much used in our country, but if you go abroad, you will see that this is widely used in building construction. Mainly because it has this reflection, you know it reflects the heat from radiant energy, and up to 97% of the radiant energy can be reflected if you use aluminum foil.

What does it compose of? You can see in this picture here two outer layers of aluminum foil and an inner layer of some inert material. So it is like a sandwich material, a sandwich product, and

typically this inner layer is made of some plastic polyethylene plastic fiberglass. The primary purpose is to create an insulating air layer in between. So you have an aluminum layer, some air layer with some bubbles etc.

The purpose of this fiberglass or polythene is to create that space in between these two aluminum layers. So that will provide much resistance against the heat you know across that layer.

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Here is an example to show you can see here on the left side; let you see this box here, there is a box-like structure here, and you can see a box here. And inside the so this temperature is fiberglass is ineffective at stopping radiant heat. But the reflective foil redirects the intense rays from the heat lamp keeps the chamber cool at 78 degrees Celsius. So, on the left side, you can see that it has an aluminum foil.

And then there is a bulb on top outside, and then they measure the temperature inside the box. So in the left case, where it is covered with aluminum foil, even though the high heat from the bulb, it cannot penetrate the box, whereas, on the right side, you can see 107 degrees Celsius. So very clearly, you know aluminum foil can prevent the entry of heat.

So, on the right side, you can see a picture this picture on the bottom right is part of a structural structure or a building. Where you can see a column, and you know a beam structure there and the wall element. So the wall element is caught, they are providing an aluminum foil on the wall element so that the more the heat does not enter into the building through that wall element.

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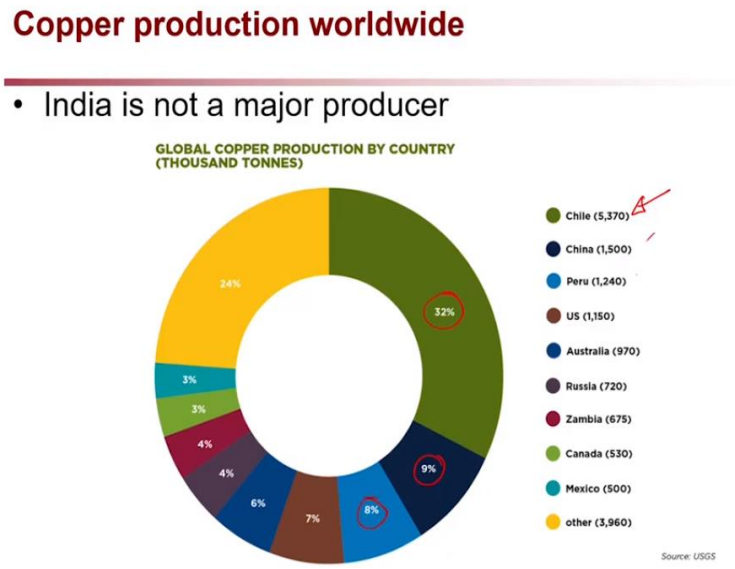

Now let us look at the next metal that is copper. Copper production worldwide, if you look at India, is not a major producer. The top producer is Chile, then China, then Peru. So Chile is about 32% China you know all others included is like a 14 so the next player is china which is about 9%. Peru 8% more or less very not a big difference but Chile you know outperform everyone else probably because of the raw material availability in that country.

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Now for making copper, mainly the oxide and sulfide ores, are the primary ores used for copper production. And these ores typically contain about 0.5 to 2% of copper, so just very little, you know, 0.5 to 2 % of copper, so you have a lot of material to be processed and lot of waste, will be generated and then so. And what are the typical ores? This is chalcocite and chalcopyrite and then covellite. So these are the typical ores that are away or which are being used.

And about 80% of the global copper production is from the sulfide source, so this is the primary copper ore used. The picture I showed on the right side is from you; know typically, like steel production or iron, you have pellets. So like that in the case of copper, they typically produce this kind of rods, large diameter rods, which is used for further production of wires, etc. That is probably why that shape is still maintained at circle I do not know, but I am guessing that way.

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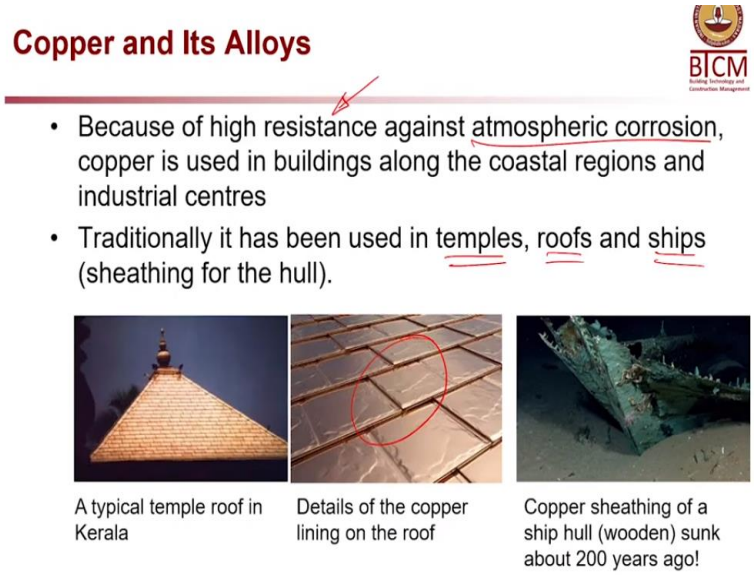

Now copper and its alloys because of high resistance against corrosion atmospheric corrosion high resistance against atmospheric corrosion. Copper is used in buildings along the coastal regions, and also wherever there is corrosivity, high copper is used. Now traditionally used in temples roof elements of temples and then, also ships, sheathing for the hull. So this protects the hull from, you know, getting into direct contact with the seawater etc.

So, on the left side, you can see a temple roof in Kerala because, in Kerala, many temples are like this, which has copper cladding roofs. And then this is another close-up of this you know how it will look like, so mainly wherever you have a highly corrosive environment, copper is an excellent product to good metal to use.

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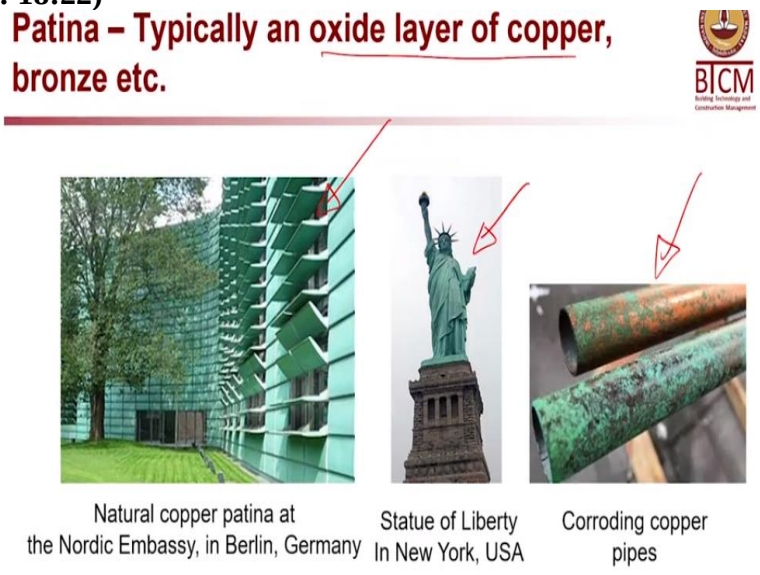

A couple of examples where the corrosion product of the copper is used for the aesthetic appearance. You can see here this is an embassy building Nordic Embassy in Berlin, Germany where these are all copper clad you know the walls, sun shades etc., are all cladded with copper sheets. And the green color which you see is the corrosion product of the copper.

The patina or the oxide layer of copper bronze means all these have this green color, right. And Statue of Liberty, you know this the color is not really the paint. It is the oxide of the copper, and then let it be there; this is a natural color it will not fade away, and you have just to see its beauty. And but this one here it is not suitable because it is a pipe when they start corroding, but I am just trying to show you that you might see this green color rust on top of that if you have copper pipes.

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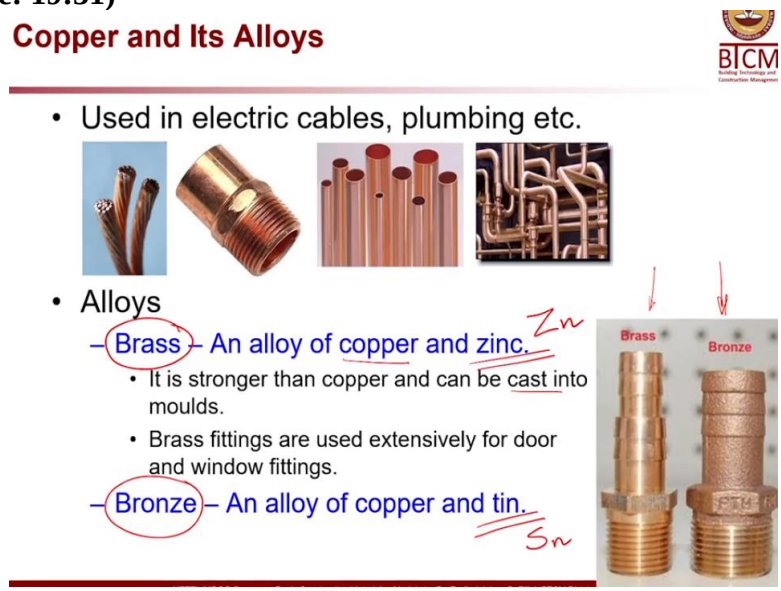

What are the alloys? There are two significant alloys one is brass, and the other one is bronze. So this copper is used in electrical cables, plumbing; you can see the photo showing different applications of copper. And the alloys are one is **brass** which is an alloy of **copper and zinc**, the **bronze** is the alloy of **copper and tin**. They are generally stronger than copper; that is why we go for this alloying process.

And can be cast into different molds or whatever shape you want, and brass fittings are used extensively for doors or window fittings. I mean, it also has this golden color, so people like its aesthetic purpose with the teak wood or in a wooden it matches nicely and then you know it is

really shiny. It is not easy to see the difference between brass and bronze; sometimes, you need to take a sample and look at them to notice the difference.

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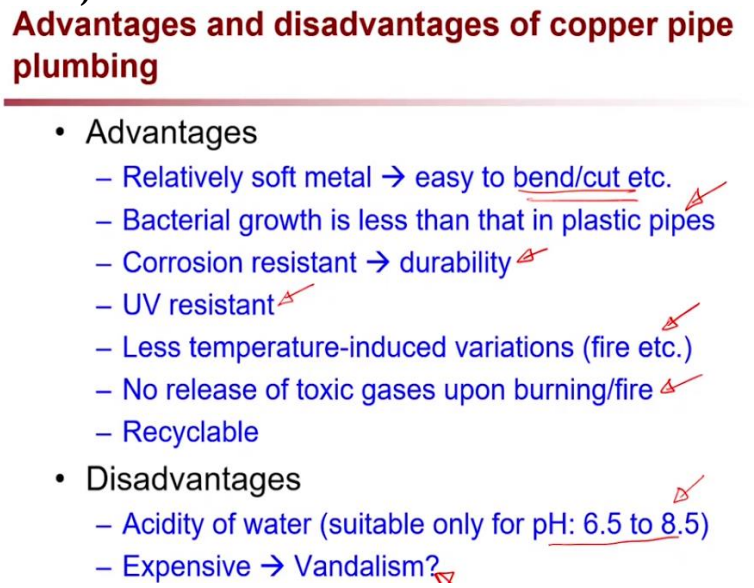

Now, advantages and disadvantages of copper pipe or plumbing. Let us look at the advantages first. It is a relatively soft metal, so it is easy to bend and cut; let us say you were talking about plumbing work. If you have very rigid and which you cannot bend or slight adjustment etc., are not possible then the workers may not like to work with it or the workability. If you want to relate to cement concrete, etc., it is easier to bend cut.

Cut to a particular size and shape whatever you want to do; it is easy to work with. So workers will prefer to use this kind of pipe rather than a steel pipe which is very difficult to cut and work with. Now bacterial growth is less than that in the plastic pipes; if you have PVC pipes or other you know plastic pipes, you will see that there are slimy layer formation, etc., inside the pipe and less in the case of copper pipes.

And also, it is very resistant to corrosion, which means durability is very good and UV resistance. Whereas if you look at the PVC or you know PVC pipes or other plastic pipes, they might not be UV resistant or not UV means ultraviolet. And after sometimes those plastics will become brittle, whereas, in the case of copper, you do not have to worry about such problems. Less temperature-induced variation if even if there is a fire attack or something if you have plastic pipes, they will melt and get damaged.

But copper pipes will stay intact for relatively higher temperatures and no release of toxic gases. If there is a fire etc., if you have PVC pipes etc., it will have all that will burn. And that means much toxic gas will come out will be released, but you do not have to worry about such toxic gases in the case of copper pipes. And copper being a metal, is easy to recycle and reuse for making the same thing.

But if you have plastics, especially if you have thermoset plastics, you cannot reuse those kinds of plastics. So that also adds value to the sustainability option you can recycle the copper pipes. Now one disadvantage of copper pipe is associated with the pH, so in most of our cities sometimes the pH value of the water you get. I have seen places where the pH value of the water is less than 6.5.

So you have to see if that is a condition copper pipe may not be a good option to go for. So you have to see what is type of solution or water is going through the copper pipe? Or where it is being placed? Whether the pH environment to which the copper pipe is exposed should be in between this range, then only it is good. Otherwise, it will not be good; it will be harmful.

And another major problem is it is you know, because it is costly people tend to steal it away or vandalism is a big problem. But that is a non-technical problem; we have to work around the system to counter that.

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So to summarize today's lecture, we talked about the production, properties, and uses of aluminum. And also production properties and uses of copper, especially in the civil engineering or construction sector. Thank you.