Building Materials and Composites
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Lecture No - 30
Non-Ferrous Metals

We are back with the last lecture of this module number 6. The module is on ferrous and non-ferrous metals. So, we have discussed in detail on ferrous metals in the previous lectures, which is extensively used in building as a structural element, be it in the form of rebar or as rolled sections itself. Now we will come to the non ferrous metals which have a certain number of advantages over ferrous metals.

We will have to know them one by one and their uses are not typical like that of ferrous metals. They are not that good in taking strength and but their major advantage is that they are resistant to corrosion, which is not much happening here, that is basically the oxidation process.

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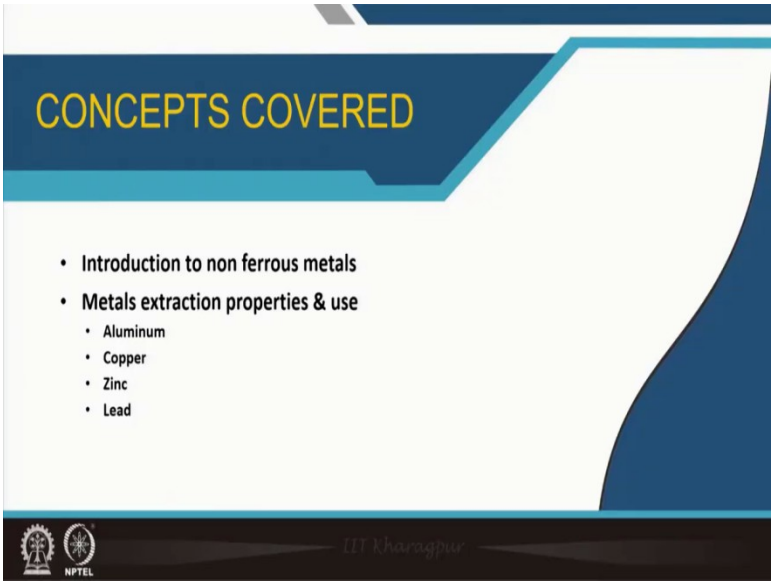

So we will cover the non ferrous metals, their metal extraction processes. Obviously, we will be very short as we had in elaborated extraction of metals, during the previous lectures; it will be very much similar to it. We will also look at some salient properties and uses. We will try to cover aluminum since it has the maximum use in building industry as a non-ferrous metal. Some

other notable non-ferrous metals are copper, zinc, lead. Previously we had also discussed tin at some point which was used in the Pilkington process of making glass.

So these kinds of metals have industrial application for building materials. Again, non-ferrous metals play a very good role in alloy formation with ferrous metals like chromium and nickel. So those are very used in a limited way and we may not ignore them. But, we will not discuss them extensively in this course.

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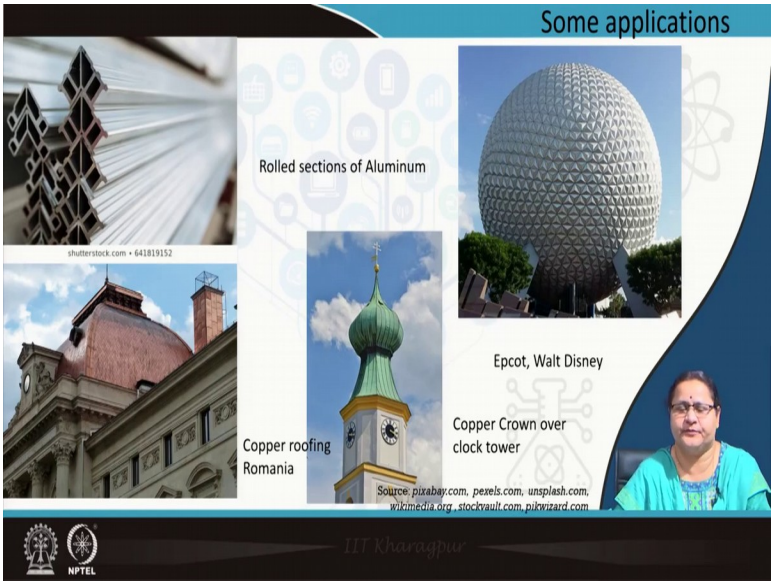

So these are some of the first few buildings where we see the application of non-ferrous metals as an external element. You see there are lots of sections of aluminum here in the picture, which may be used as an external element for a false wall (clad wall). This wall is a curtain wall which is not actually taking load, but it is helping the aluminum bars for holding the glass in position.

So this is used externally to avoid the corrosion component. You see another building which is in Walt Disney, an Epcot structure, where you see this is also entirely made of aluminum panels. Some 11000 panels have been joined and assembled together to give this kind of such a spherical shape! So aluminum is very soft metal. Now we see the other two pictures, both are made of copper. It is copper roofing where copper has been used to seal the water entry, to make the structure airtight.

But you can see there is a difference in color. That is due to the oxidation of copper in this picture where it has become green. But in the other picture it has retained its luster (shine). So some inaccessible portions like a clock tower top, where no one will be visiting, ever in say hundred years, copper is the answer. You will see lot of old buildings, churches and turrets; they are having copper tops roofing. So it is maintenance-free. And how has this color come? That is due to the oxidation of copper. We will come to that.

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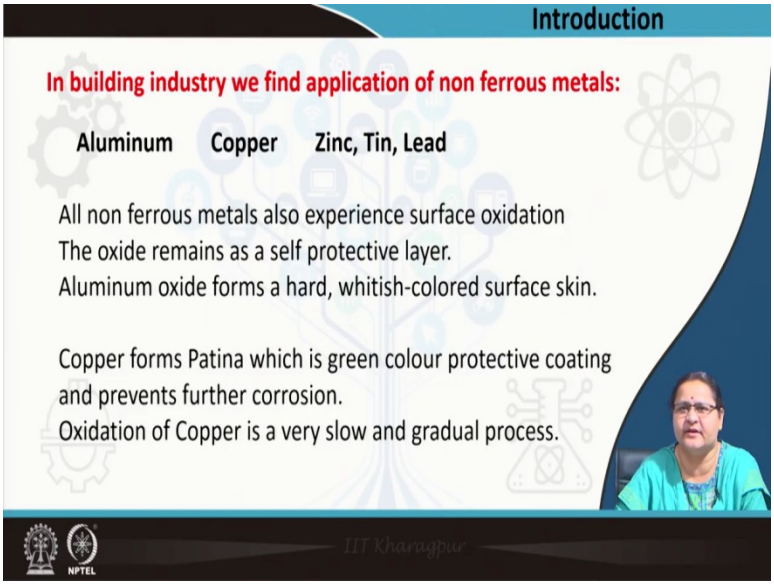

Now, in building, we find aluminum, copper, zinc, lead and tin. All these non-ferrous metals also experience surface oxidation like corrosion of ferrous metals. But in case of ferrous metals, this ferric oxide or rust used to increase in volume and peel out, create pressure and come out and finally expose the next layer. In case of aluminum or copper or zinc, the oxide formation is happening similarly, because they are similar to metals.

But what is not happening is that it is not falling out. So, it is creating a self-protection to the ferrous metal. So, this self protective layer is protecting the inner metal and is not allowing it for further oxidation or weakening. The green color what you had seen for case of copper is nothing but copper oxide which is also called patina and that is the protective layer. The green color intensifies more if the copper is more exposed to the atmosphere.

So, this copper patina is nothing but the oxide of copper which is actually protecting the copper from further oxidation and decay. Hence this is the major difference between ferrous metals and non-ferrous metals though non-ferrous metals are not that strong, but they are capable of taking up some other tasks in buildings which the ferrous metals could not.

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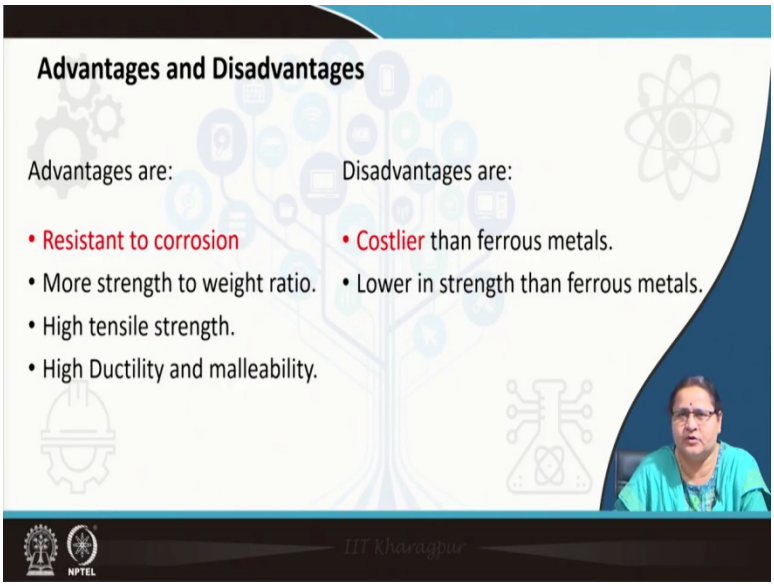

So the advantages are: it is resistant to corrosion, it has more strength to weight ratio meaning they are light, they have high tensile strength (not comparable to that of ferrous metals), they are also ductile and malleable. So you can have them in the form of sheets, you can have plate forms as you had seen in case of ferrous metals. They can be made into wires also. Some of the disadvantages are that it is not abundantly available like the ferrous metals i.e. iron ore are available but extraction process is also expensive.

Since the non-ferrous metals exhibit lower in strength than ferrous metals, they cannot be used as structural elements. That means they cannot be used as reinforcement bars, neither can they take heavy load like a structural load a building, cannot be standing on aluminum rolled sections. But yes, they can take lighter weights.

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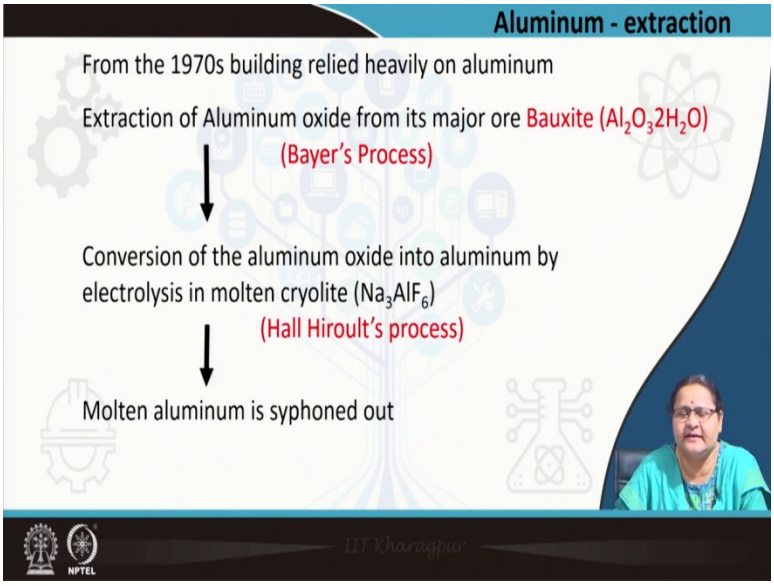

Let us look at aluminum, which has been used extensively since 1970s. It has replaced wood particularly in case of doors and windows. Yes, ferrous metals also had taken its place. But, due to the problem of rusting and also it looks aesthetically pleasing, aluminum has taken the place of wood. So, since 1970s, the buildings are relying on aluminum.

Internal partition walls, the framework are mostly built of aluminum because they are not load bearers. They are only separators. Earlier it was made with wooden structures, wooden framework and maybe with glass. Now all of them are replaced by aluminum framing. You can easily find aluminum framings if you visit some office interior, if you enter into some small office where lot of partitions has been done, if you enter into a computer laboratory where cubicles are made.

So let us go into the extraction process of aluminum. The main ore or the major ore is bauxite and we use the Bayer's process to get this aluminum oxide to be converted. Then, we follow the whole unit process by electrolysis, in molten cryolite and we get pure aluminum. So, these are the few steps. So you need to know these steps like electrolysis are done and then aluminum is siphoned out in its pure form. But remember, aluminum is very soft in its pure form. In order to use it for the building industry, one needs to alloy it.

So, we have to mix other metals with it to make it usable as a structural member. So, we will come to that gradually after we finish the properties.

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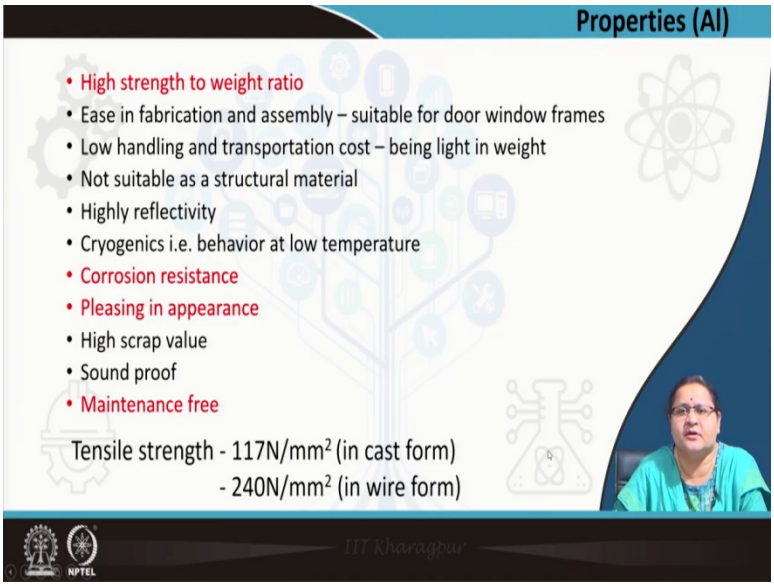

Aluminum exhibits property of non-ferrous metal. It has high strength-to-weight ratio, easy in fabrication and assembly. That is why it is suitable for doors, windows, frameworks, any kind of partitioning frameworks. Being light, it is easy to handle, transport and cost is obviously less. It has a shine i.e. it is highly reflective when light falls on it, but it is not suitable as a structural member.

But this luster gives it a aesthetically pleasing value. It behaves well at low temperature which might be problem with ferrous metals, it is corrosion resistant that is it prevents the oxide formation on top. It also has a high scrap value; you can get almost 100% return from the aluminum which is actually unusable or it has to go back to the factory for reuse. It is soundproof and obviously maintenance-free. You do not need to paint aluminum.

You need to paint wood, to protect it from moisture, to protect it from termite attacks etc. You have to paint ferrous items, say a ferrous window frame, regularly or galvanize it. In this case aluminum will stand as it is. It does not require any paint on it. Coming to the tensile strength, you see in cast form, it is 117 N/mm^2, in wire form that that is when it is ductile it is 240 N/mm^2. So it is much less than that of Steel.

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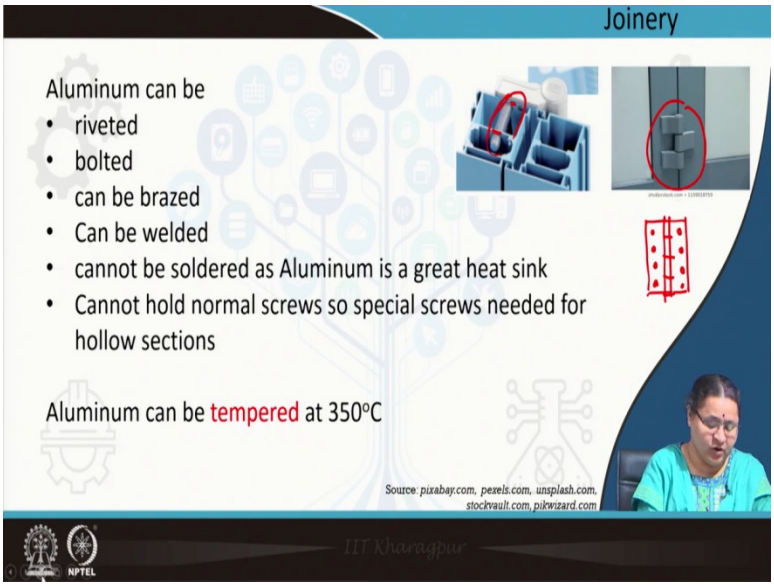

Let us take brief look on the joinery part because as you see doors, windows, etc are being made. Aluminum can be riveted, bolted, brazed and welded. We have gone through all these processes in details. Riveting is a permanent kind of joint. Bolting is temporary as you can unbolt it, but what you cannot do is soldering because aluminum is a great heat sink.

Soldering may be done at a very low temperature (300 ^{o}C), the aluminum draws the heat. So you have to keep on heating it more and more so that temperature is favorable for soldering. By that time aluminum, which is actually melting at 660 ^{o}C, soldering may be a difficulty. Yes, there are ways but it is usually not recommended.

You need special types of screws for aluminum hollow sections. If you look at this picture you can see it is very different kind of hinge, holding two aluminum surfaces. If you take a closer look, you can see here, that the screw is not like the regular screw. So, this has gone through, it is held at this thin section at two points.

So this is a kind of a section through the hinge, through the frame, where you can see how it has penetrated inside. Here what you see from outside is quite unlike the other hinge, which we regularly see the door in home. You will see here are, this is a very common hinge what you can see. But in case of aluminum doors, windows, you have to use such kind of special screws.

And hence if you observe correctly, you will see, most residential uses aluminum windows, which are sliding. So, usually it is avoided to make it hung. That is side hung windows. For these types of windows you have to have the hinges with the frame, which is avoided mostly. Sliding doors are preferred now-a-days. It is preferred because the special types of hinges are not required.

For hollow sections, aluminum can be tempered at 350 ^{o}C. The major points are written for you and the discussions will help you for better understanding.

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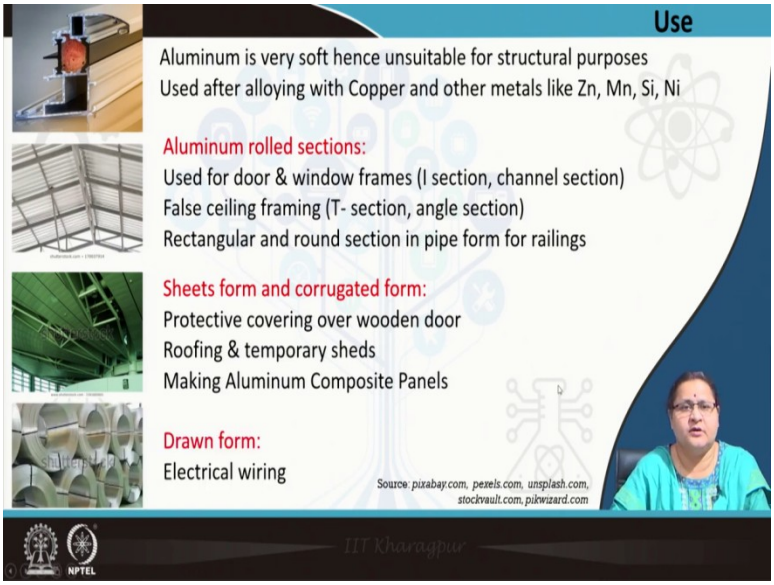

So as I told you, coming to the use of aluminum, it is a very soft. You need to alloy it with copper, zinc, manganese, silicon and nickel. So, different proportions are required and we are not entering into the metallurgy part. We need structural aluminum and for that whatever is suitable, we will get it from the market. Aluminum can also be made from rolled sections; we have extensively discussed rolling of steel the same way aluminum is rolled out.

You will get same kind of sections, I Section, channel section, T section, angle section, rectangular, round section, hollow section. So, whatever you get for ferrous metals, you will get for aluminum. But they cannot take much load. Aluminum is used in false ceiling, where from

the main roof, you may see that suspended aluminum. If this is the main roof suspended aluminum frame is there and you have to put the false ceiling supported here.

So, this will be the T aluminum section. At the end of the wall there will be an angle section. So if you see a grid (in the picture), you will see these are some false ceilings, which are resting on such T sections, angle sections. If you happen to see some false ceiling, you will see the gypsum boards are placed and the edges are actually metals, which are all aluminum framing.

You can get sheets of aluminum which are laid, they may be corrugated, and they may be flat. They can help in making temporary shades. They are used for aluminum composite panels. We will come to that also and it is also available in wire form, which is much used for electrical conduits wiring.

So similar to ferrous metals, we can see in just keeping aside the structural loading, all the things that is possible with aluminum.

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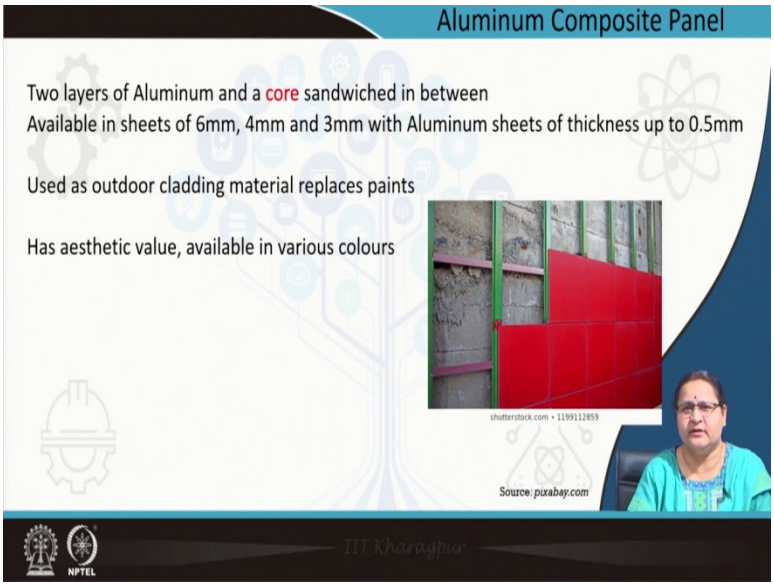

In case of aluminum composite panel, these red panels in the picture are fixed to a frame and you can understand inside there is a wall and you get a beautiful cover. So, the ugly thing which was seen is now with a frame is clad with or coated with a beautiful colored finish. So this is not a

plain aluminum sheet, you see the word composite is there. Composite means it is combination of two aluminum panels with a central core.

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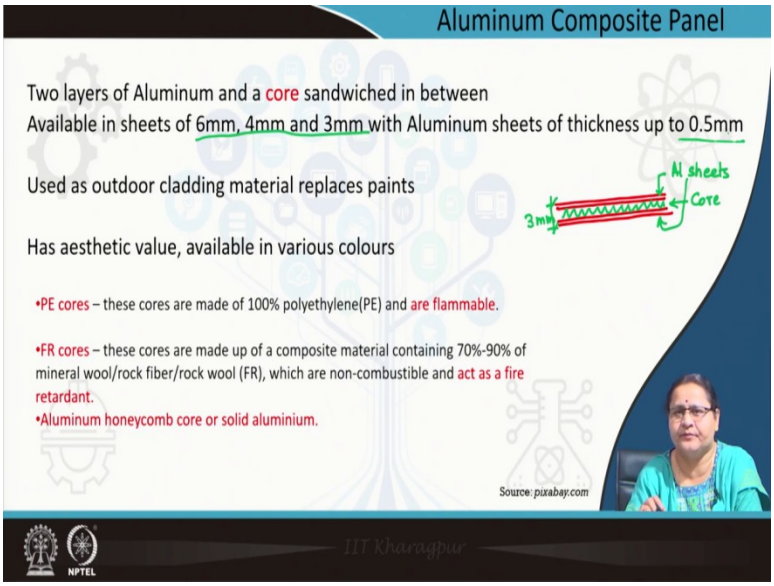

The core is usually sandwiched in between the two aluminum sheets with an overall thickness of as low as 3mm. The standard thickness is of 3 mm, 4 mm and 6 mm. The aluminum sheets are of 0.5 mm in thickness. So, you can understand how thin the sheets are! It is not even a millimeter thick. And the central part is the core, which is either the poly-ethylene (PE) or fiber or rock wool core.

How are they different? PE cores are flammable. So, if you want a safer wall, say for cladding, you can use FR cores. And sometimes, aluminum honeycomb core is also available where less of aluminum is used and there is a separate core. So, these are combined under pressure and these sheets are available in market as a cladding member.

And in many places you will see paints are being replaced to give an aesthetically pleasing look with beautiful colors combined together. These are aluminum composite panel facades. You can find these types of facades mostly in urban areas. The only drawback of using these panels is that they are very much flammable. Mostly it is the PE cores that are used and they are highly flammable.

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Now let us look into the applications of copper. It has been used in the Copper box Stadium in 2012 London Olympics, in the Jurassic Museum in Spain. If you take a closer look, museum resembles like of a paw for dinosaur and hence it is a Jurassic Museum. All of them are very modern buildings.

All the roofs you see are made of this copper. Pronounced architects like Errow Sarrinen, Frank O Ghery and Renzo Piano;all have used copper as a prestigious element or metal. So, you can see these structures and we will quickly go to the extraction process.

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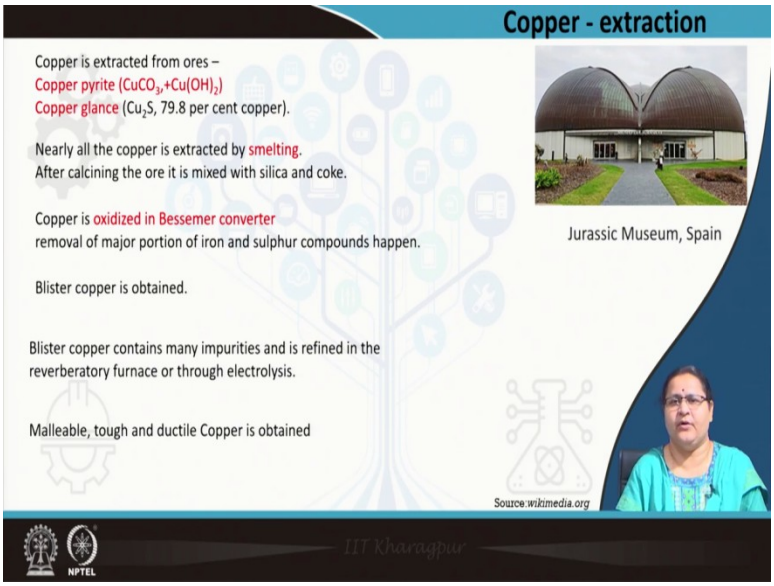

The ore is copper pyrite and copper glance. One is carbonate and the other one is sulfide. High temperature is involved in the smelting process, which is heating at high temperature. Calcite is extracted after calcining the ore and the oxide is formed after putting this first extracted metal into the Bessemer converter. Removal of the major portions of iron, sulfur compounds happen in the Bessemer converter. It is a very similar process where blister copper is obtained.

Blister copper is then made into pure copper just by taking out impurities through the process of electrolysis. In case of copper, the electrolysis process is very important. Hence the extraction process becomes little costlier. After the extraction malleable, tough and ductile copper is thus obtained.

Copper is a prestigious metal which has been used extensively in chapels building tops, roofs and inaccessible parts of a building, in earlier days.

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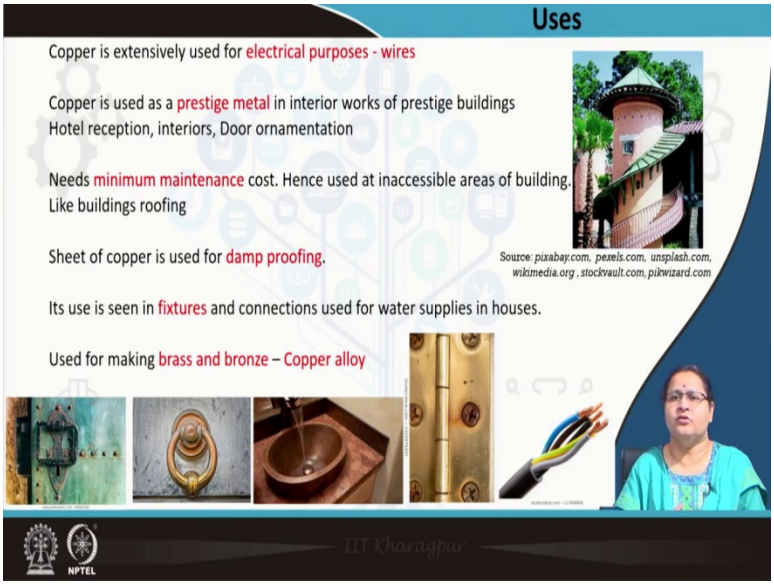

But presently many famous architects are using it and we also generally recommend it for, say, star rated hotels, interiors, doorknobs, sanitary wares, making of brass fittings, where copper is one of the key ingredients. The first picture you can see it is from a very old chapel, where the door has actually become green. The door has a copper covering.

In this, this is a brass knob which is a copper wash basin. These are in very common in rich and renowned hotels. So these kinds of interiors you can see, it can be some ornamental item in a hotel reception. And as you all know copper in wires are used for electrical connections. Brass and bronze has good percentage of copper in it. And brass is used for also used for hinges, that is building hardware.

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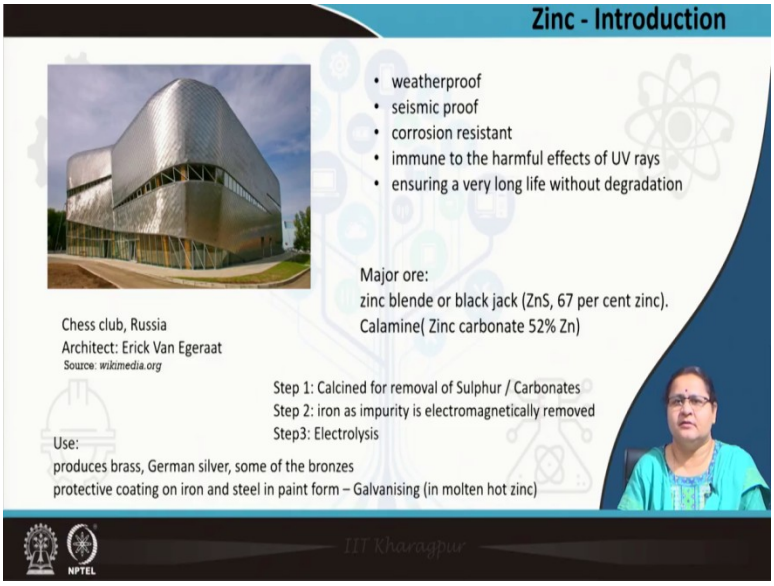

So we come to the next non-ferrous metal which is zinc. It is weatherproof, seismic-proof, corrosion resistant, immune to UV rays, ensures very long life without maintenance. Zinc is mostly used for galvanizing, as you all know. One common example is the Chess Club in Russia but zinc is mostly used for galvanizing across the world. Zinc blende or black jack is one of its ore and calamine or zinc carbonate is its other ore.

And again you calcining is the very first step which involves removal of the sulfur or the carbonate. Then through the electromagnetic process iron is removed, since it acts an impurity. Finally with the help of electrolysis, the pure form of zinc is extracted. Zinc is again used as an alloy for making bronze, German silver and galvanization is the other or the key purpose which we as architects need to know.

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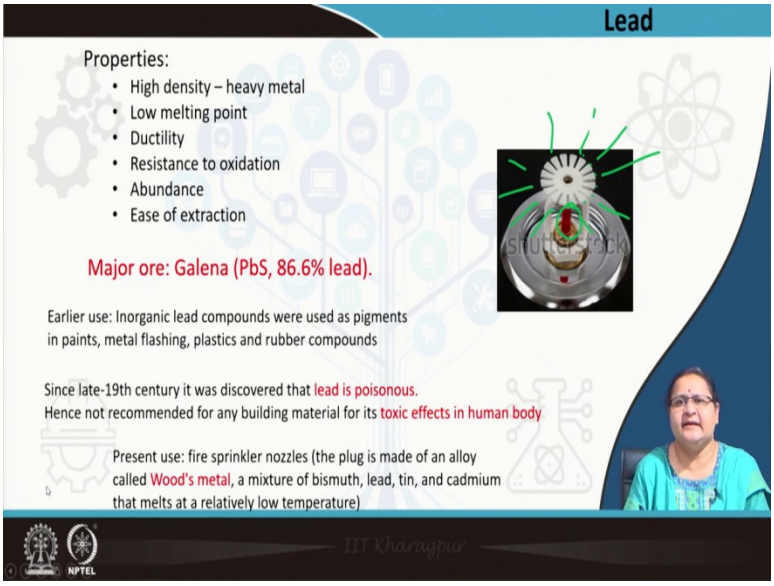

Now we have another important metal left which is lead. It is important to mention that it is no longer used in the building industry. In the past it had enormous application in making paints, mainly as a pigment in paint and in metal flashings. It was also used in plastic and rubber industries but because it is poisonous (found in the late 19th century), the Pollution Control Board has banned it.

It has toxic effects on human body. So lead is no longer used as base for paints now-a-days which has increased the cost for paints. The major ore is Galena that is again lead sulfide and it is a heavy metal with a low melting point.

Due to the low melting point, it finds application in making Wood's metal, which is used in fire sprinkler nozzles. What happens there? When there is a fire, you see here there is a red filament here. The red filament senses whenever the temperature rises. The nozzles have Wood's metal plugged in, which due to its very low melting point, the nozzles open and the water gushes out. Water comes out from all the points of the sealing of this sprinkler and controls the fire.

So we use Wood's metal for this for sealing these sprinkler nozzles and actually it is bismuth lead, tin and cadmium alloy which is used to plug in these nozzles. So, this is where we find the application of lead till date. We had discussed, we have talked of tin earlier for the Pilkington process. We get tin in sheet forms. Those are very low cost items, mainly used for low cost

temporary structures. We use chromium in alloying purposes and for getting stainless steel we use nickel. So there are so many non-ferrous metals but we would like to close it with all these discussions and end this module here. Thank you.