Building Materials and Composites

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Lecture No - 28
Ferrous Metals 2 – Steel

Hello everybody. So today we will start lecture 3 of module 6. We have already covered cast iron and wrought iron and we told that we will carry on with ferrous metals, particularly steel, which we are presently using in our building industry quite extensively.

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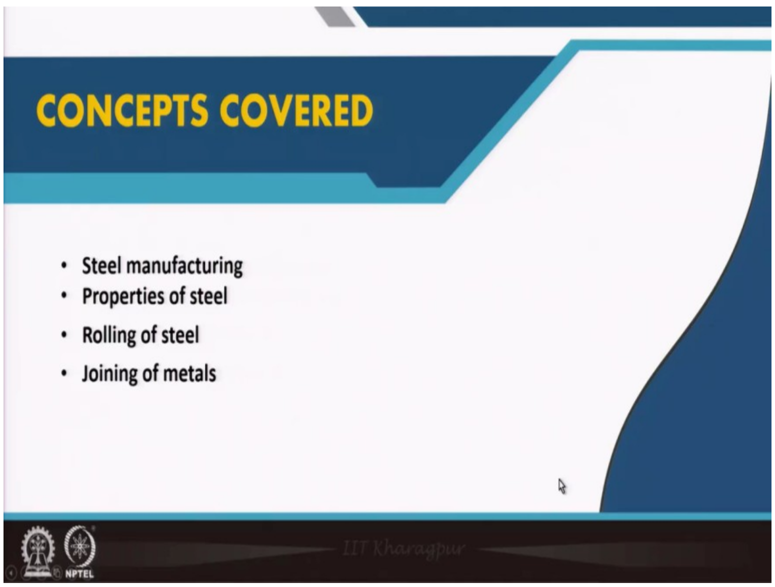

The items that will be covered in this particular lecture are the manufacturing of steel, then briefly on the properties of steel and then rolling of steel and joining of metals (particularly steel). So we understood in our previous lecture that you need pig iron which was extracted first in the blast furnace and then it was used for either making cast iron or wrought iron. So the same pig iron comes here and helps in the manufacturing of steel.

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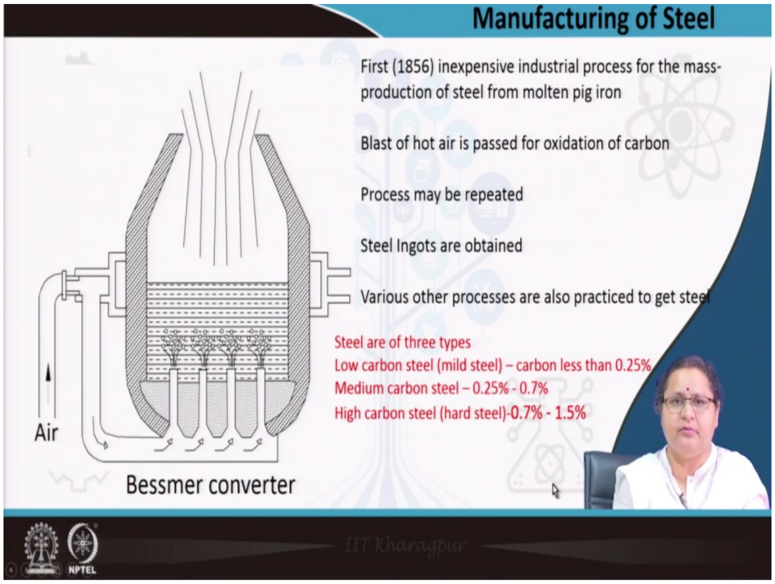

So the first industrial production of steel started in 1856 and since then we find the replacement of cast iron and wrought iron by this particular item and steel is now extensively used replacing cast and wrought iron into building industries, into bridges, highways. roadways etc. So the principle remains the same. Here again if you see the picture this is a Bessmer converter which was first used for large scale production. It is having the same concept of pushing in hot air as you can see the hot air is bubbling out into the charge.

What is the charge? Here again it is the limestone and the pig iron and on the upper part the slag actually comes up and the steel is tapped. So here again it is the hot air heating the entire charge, the slag is coming out and the metal is being extracted. Various other processes are also practiced to get steel. The steel Ingots are obtained and they are now taken for further processing. Now steel is again of three types: low carbon steel, medium carbon steel and high carbon steel.

Low carbon implies that the carbon content is less than 0.25%. So it will resemble characteristics more of like the wrought iron and it is called mild steel. So you can understand the tensile strength will be less for mild steel when compared to that of high carbon steel which resembles more of cast iron. But you see here the carbon content in case of high carbon steel is restricted up to 1.5%. These are the metallurgical aspects and I am not extensively telling you on that.

Carbon at 1% gives the best kind of steel. So you see if the carbon content goes beyond 1% again the qualities go down. The best is getting steel at 1% carbon.

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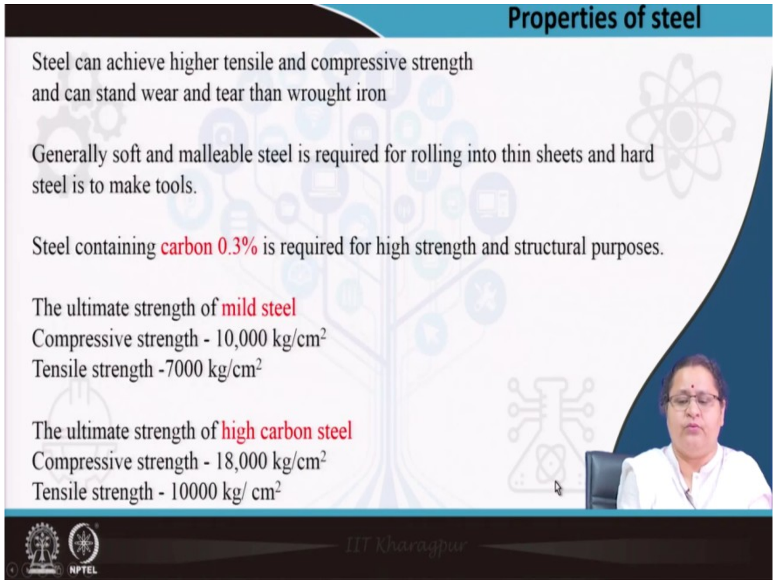

So we see the different grades of steel are available. For the three types of steel i.e. low carbon, medium carbon and high carbon, we see that the properties is it can achieve are higher tensile and compressive strength, it can withstand wear and tear better than wrought and cast iron. It is soft and malleable, it can be rolled into thin sheets and hard steel can be used for making tools. If you remember in the previous lecture we had given a diagram where various types of steel were in between cast iron and wrought iron.

So with more carbon content steel will resemble cast iron which will be useful for making tools. Steel containing carbon of 0.3% is required for high strength structural purposes. And you see the two values are given the mild steel is having a compressive strength of 10000 kg/cm^2. The tensile strength of mild steel is 7000 kg/cm^2 and the same is given for high carbon steel.

Similarly high carbon steel will have higher strength i.e. 18000 kg/cm^2 (compressive) and 10000 kg/cm^2 (tensile).

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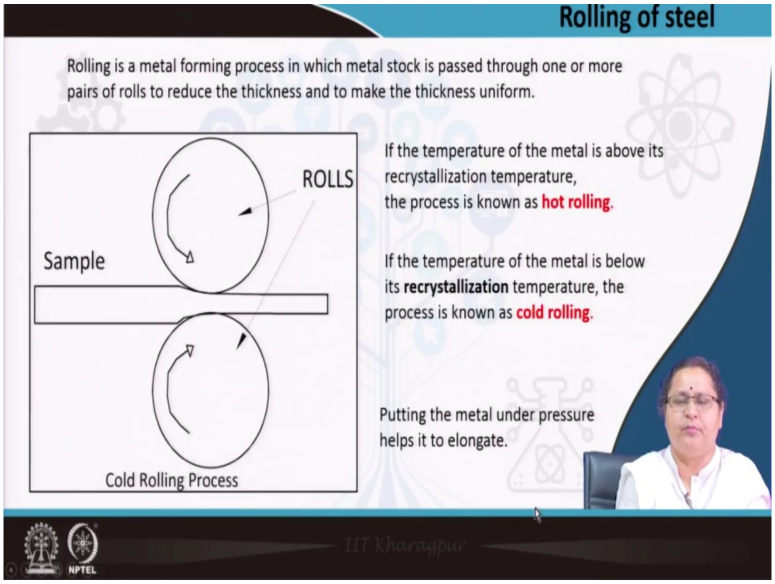

Now let us come to the process of rolling of steel. Why we are coming to this because we as architects need to know how to use steel into the building industry. After knowing the basic properties, like we all know steel is good in tension; we will have to make use of it into our buildings. We also know it is very heavy, so we have to think of light weight proper sections to be used which will be more effective.

So we cannot just not take a big rod of iron or a piece of large bar of steel and use it as per our will. We need to know how best we can use it and that is why we need to know rolling of steel. It is a metal forming process in which metal stock, which is instead of taking the entire log of wood or taking an entire steel piece we will roll it into our desired shape, desired thickness, and uniform cross section simply by pressing it. So if it is in its molten form it will be easier. By molten form it means not 100% molten but at a temperature where it can be easily passed through rollers without any deformity.

So one type is hot rolling other type is cold rolling. So the metal, when it is passed through the rollers under pressure it is at a higher temperature. If the temperature is below the re-crystallization temperature it is called cold rolling. So if we are doing cold rolling we are not changing the crystalline structure inside the steel. If we are going for hot rolling we are changing the crystallization pattern inside the steel.

I am not elaborating much but we will see in one case where how this thing works. So the TTT diagram is there which I have not covered in any of these lectures on this module. The time temperature transformation diagram of steel that gives a vivid explanation though we need not know need not know so much of details. So just by putting the stock under pressure of rolls we get different cross sections which can be used for our purpose. We will go into that little later.

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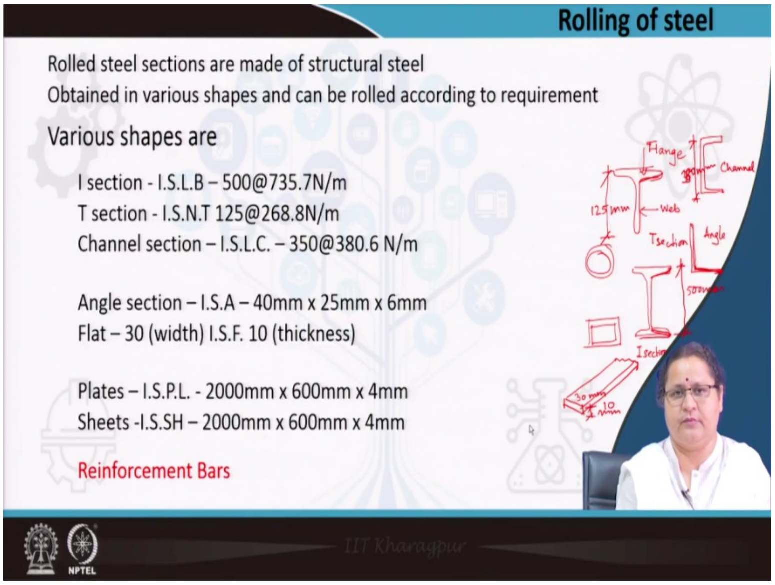

So these rolled steel sections can be directly used for structural purposes. And I have told you we can get different shapes of it. The IS code is there which gives the details of such shapes. Usually there is a thin member known as web and a projected member that is called the flange present for every member; say if it is in I section, now you can I think understand what I mean of this rolled section. It can also be a channel section, it can be an angle section, it can be a hollow circular section, and it can be a hollow square section as well.

So this is called I section, this is a T section this is an angle section, this is a channel section etc. So you see here it is written as ISLB which is I section as per code it is written 500 @ 735.7 N/m. That means 500 is the depth of the I-section in millimeters (mm) and 735.7 N/m is 1 meter length weight. Similarly for T-section, it is ISNT 125 that means the depth of the T-section is 125 mm and the rest is the weight.

Same with the channel section you see ISLC 350 @ 380.6 N/m. Here the depth is 350 mm. So these are all codes specified. So you just cannot order any number which you desire. So there are lists in the code and you have to order based on it the weights are also given and you will see all these items have an inner slope.

Angled sections will also have an inner slope. It will slope outside meaning it will be tapering at the outer end. The angle section ISA 40 x 25 x 6 mm. Here the weight is not given. '40' represents length of one of the arms, other arm length is 25 mm and the thickness is 6 mm. Coming to MS flats that is you can see on top of railings, you can see a flat bar like this, this is 30 mm wide and 10 mm thick and having a length whatever you desire.

You may have plates and sheets ISPL ISSH that gives the dimension of the sheet see 2000 x 600 x 4 mm or 2000 x 600 x 4 mm. So these are the various types of rolled section available and these can be directly used for construction purposes. Why I mention this because other than these we have reinforcement bars. Reinforcement bars abbreviated as rebars, which are actually embedded in concrete.

When we had covered concrete we had understood reinforced concrete. Where reinforcement was embedded inside concrete to take care of the tensile forces which a structure would experience because concrete was good in compression but not good in tension. We will cover reinforcement bars in the later lecture but now we will carry on further with the rolled steel.

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Here you see a number of pictures which I could collect. The sources are mentioned. These are angle section, box section or rectangular section. You can see channel section, circular hollow bars, steel plates and or even the rebars or the steel bars. You can see these in your daily life daily places where you visit. A cycle stand, a temporary kind of shop where you will see circular hollow bars, steel angles being used for putting up the roofing or temporary roofing or weight roofing on top of a structure.

A temporary garage temporary structure will also have rolled sections. Try to look around you will find all these kind of sections. Even the railway tracks those are kind of T section those are also rolled out. So rolled sections are directly used in structure they need not be embedded inside concrete. So rolled steel is used directly for steel structures. Even steel sections made for steel structures for building industry. We can see steel structures completely where reinforced structure reinforced columns and beams are replaced by steel members.

Sometimes an intermediate support is required there you can actually put a steel member as steel is both good in compression and tension it does not need concrete along with it. But concrete requires steel along with it. These steel structures wherever used they are very stable and they can take load be it tensile or compressive. Hence I sections T sections can be seen used for steel structures.

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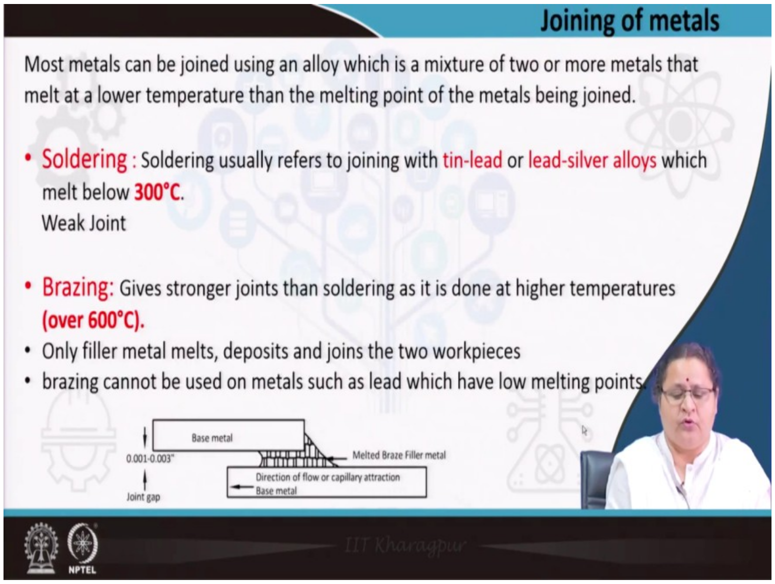

We now come to the most interesting part of joining metals. Once we get these rolled items how do we join them together? In case of bricks we had seen mortar was joining the two. In case of engineered wood we found adhesives joining the two. In case of metals how do we join them? If you want to directly join two pieces we have three processes namely: soldering, brazing and welding. Both soldering and brazing requires a second metal or a metal alloy which is a kind of adhesive between the two mother metals or the metals that is to be joined.

So if you have two metals to be joined, you are putting a third metal liquid in between and allowing it to join. This third metal should have a lower melting point. Soldering is usually with tin and lead alloy or lead and silver alloy. This alloy melts at 300 ºC. So what is happening that at 300 ºC when the mother metal is not at all melting or is just getting heated, this third metal comes in between in its liquid form and it holds the two metals together once it is solidified.

But this is a weak joint. Brazing also has the same type of joinery. Here the temperature is little higher that is 600 ºC and the filler metal passes in between the two metals. The gap is very small but even then these are the two work pieces to be joined and the third metal or the metal alloy percolates in between the two.

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But welding is little different. What happens in welding is that the metals which are to be joined are heated to almost its melting point and then when it becomes soft the two pieces are hammered together (traditional way). Now different easier methods have been found out but it is the same two metals being joined there is no third metal or any other metal coming in between.

But even then these points are weaker than the main material but this is the strongest amongst the joints. So let me summarize by saying that in all these three cases you are using heat, bringing another metal into the application. When you are using heat, it is the third material in its molten form is getting in between the two metals to be joined. The entire process happens at a lower temperature which is called soldering the other is called brazing.

Welding gives a better and stronger joint and no third metal inside the process. There are modified or easier methods of welding such as gas welding, arc welding, etc. For welding the person has to wear a mask and doing the welding.

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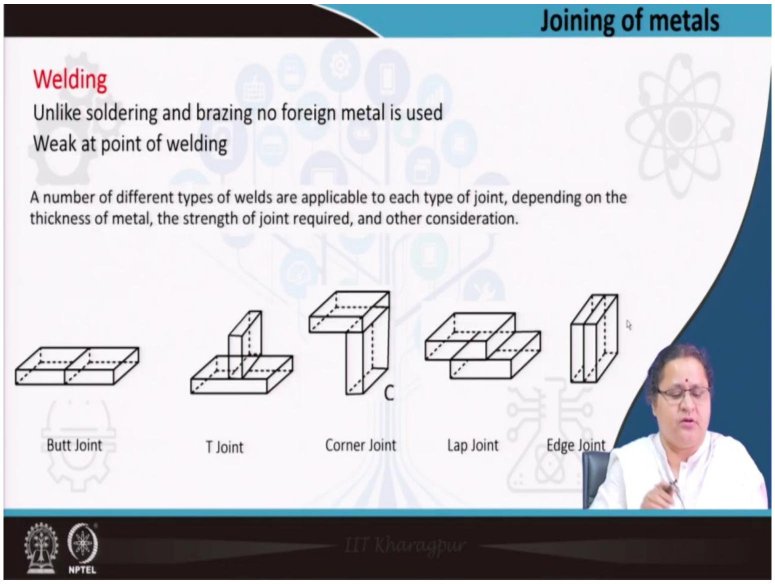

There are different types of welding. See the butt joint, T joint. Butt joint is placing one beside the other; similar to the case of wood, if you can remember the lengthening joints. Here you see you want to make a different picture, more complex structure. Here you see it is a corner joint. So this joint is very important here. This is a lap joint that is overlapping with the other member and this is an edge joint.

So these two items are joined together to even increase the thickness. So all these are possible with soldering brazing as well as welding and you can see these are quite similar to that of your wood joinery.

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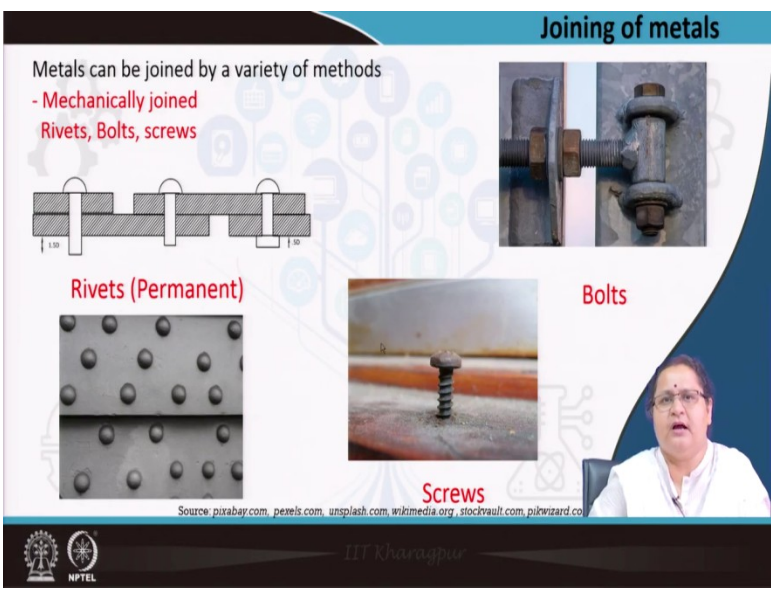

There is another kind of joint that is the mechanical joints; which can be done to join two items allowing some movement, allowing some possibilities. we see rivets, we see bolts, we see screws. This picture is rivet which is a permanent joint. See the cross section here where you see the pin and the shank is passing through the two metals and on the other side it is hammered and it becomes a flat. It is completely sealed you cannot open it unlike this nuts and bolts.

You can screw you can open it through the thread. It is being fixed together and this allows movement. For example say you want to have a hinge kind of thing so that it will move. So nuts and bolts are temporary kind of joints. You can open it and again fix it. Screw is also the same you can unscrew an item. So rivets are permanent kind. You will see more riveting is done for steel structures where it becomes a rigid body. You can see screw in case of structural steel members, where you can unscrew it.

You can find applications of nuts and bolts where again you can take out the nut, you can take out the bolt and again use it for some other purpose. So with this we end this lecture that is lecture 3 and we will move to lecture 4 where we will discuss more on the rebars or the reinforcement bars. Thank you.