**Building Materials IV**

**Lecture 2**

**Mechanical Treatment**

Let's start with mechanical treatment.

Mechanical treatment is nothing but how steel can be altered in terms of its physical properties so that it can better assist its requirements. So the mechanical treatment of steel, through its influence on a structural units of the metal, is as important as any phase in the production of a suitable finished product. So mechanical treatment of steel not only steel but any metal for that matter or any material is important in order to reach its final byproduct. It has the most profound result in perfecting the physical internal structure of the metal, as well as in shaping it for the use desired. So you look at two things the internal structure should be able to withstand the function that it's going to serve as well as the shape should be suitable in order to be serving the use it is desired for. The four great methods of shaping metal are pounding or hammering, hammering is something that's been done since the beginning of time since cave ages, rolling of metals, squeezing in hydraulic processes and drawing as in thin bars and wires, so drawing a ductility and malleability and finally Forging.

So Hammering we'll look at hammering first. Hammering is the most ancient method, and is used largely still, in connection with the crucible process. So if had to look at villages or village blacksmiths whoever are handling metal in villages or rural areas even in India today they use the most basic process of hammering the metal out and so hammering is important method even as far as steel is concerned. So hammers have been built to very large size, but are subject to certain mechanical defects and cannot compete with other methods of forming in the shaping of most objects. So even if you had to walk into a construction site today in India you'll see that hammers are extremely used and they are used a lot to change the physical properties of any particular materials especially steel and reinforcement rods. So it might not be the best method to mechanically change its form but still it's a very viable method. Hammering gives an especially good working of the surface layers of any object, so when you're hammering a particular metal you're directly coming in contact with its surface so you have a direct control over its surface, but, as the impact is transient, the core of the metal is less worked by this than by any of the other three methods. So as I said you directly treat the surface which means the internal core structure is directly not touched or nor dealt with its actually a disadvantage as far this method of mechanical treatment is concerned. So as I said it's been used from immemorial its been used to make a lot of weapons so hammering and sharpening is how the metal was treated mechanically. So even in hammering there are very different ways of doing it, so there's Lengthening vs Curving vs Chasing and Flanging. So even today when you have to particularly season a weapon or season any sharp instrument you have to go through the various types of hammering that can be done. So Lengthening- Lengthening means elongating or combining elongating and widening of work pieces. So you notice that sheets are sometimes beaten and widened and elongated in order to be used in a particular type of purpose so that's a type of hammering. Curving means one sided lengthening of sheet metals strips or strip steel to

give a two dimensional curved shape. So that is how curving is a type of a hammering and its done to the metals. Chasing means three dimensional shaping of thin sheet metal. So after its made into sheet metal so after metal has been drawn into sheets it can be further treated in three dimensional forms so that is called as chasing. Flanging means bending down of borders of metal sheets obliquely or perpendicularly too the plane of the sheet. So you take it to the next level of bending and chasing and flanging is a type of hammering that requires that.

Next we move on to Rolling we'll be talking about rolling steel and cold steel etc. So this is actually a method that was evolved from this basic rolling. Rolling of metal is the most rapid of all process of shaping. So what you do is you particularly draw a metal into sheets or into other thing sections then you roll them in order to make them into different shapes even for domestic applications as well as for large scale applications. If the metal is used at a rather high temperature, it will offer little resistance, to shaping and can be passed through the rolls at an extremely rapid rate. So this is nothing but hot rolling, what happens is you take a metal you rise the temperature to which it comes in contact with and at such high temperature it becomes resistive to any kind of shaping. So at this phase it can be shaped and can be used in various ways and its rolled at high temperatures in an extremely rapid state. Care must be taken always that rolling speeds are not too great nor exterior layers drawn by excessive differential motions, so that has to be taken care of. The effect of squeezing in rolls is more prolonged than by hammering, and rolled materials may have a well worked core. So we noticed that hammering is a good way of doing its the usual way of doing it but had the basic disadvantages of not having treated the inner core with rolling that has been addressed so the effect of squeezing in roles is supposed to be more prolonged or more lasting when compared to hammering and the rolled material may have a well worked core, so the core is also addressed in this case. So that's one of the ways in which thick section is rolled. So the ingots, while still red hot, are passed in succession through different rollers until articles of desired shape are obtained. So what happens is Ingot Ingots are nothing but cuboids of the metal so that is passed through red hot heat and then after this it is subjected to the rollers which change the shape of the ingots. Various shapes such as angles, channels, flats, joists, railing etc. are obtained by the process of rolling. So when you take any form of construction that is large scale construction that is addressed today in large spaces in constructing airports and railway stations the use of angles, channels, flats, joists, beams etc. are very very essential and these are formed such that they use the process of rolling to create them. It is possible to prepare joint less pipes with the help of this process. So pipes need not necessarily have joints which make them brittle so this can be achieved by rolling metal continuously in a given form so this is an another way of doing it. The solid rod is bored by rollers in stages until the pipe of required diameter and thickness is obtained so that's how it is done it is bored by rollers in stages until the pipe of required diameter and thickness is obtained.

So the next process of how you mechanically treat metal or in this case steel is mills or milling. Rolling mills are built in conjunction with nearly all steel plants, and shape up the material into billets, slabs, bars, plates, rails, structural forms, any which form that you require. The self-acting rollers of the tables hurry the heavy lengths of metal into gap between the two horizontal rolls which revolve, in one direction, and the other, according to the pass. So rolling mills is nothing but bunch of rollers put together so you pass the metal in between the gaps and the way they are shaped out is how the mechanically treated thing becomes viable. So each time the rolls will be closed a little between passes so that the ingot soon is reduced much in cross-section and is made longer. So step by step the gap in

between which the metal is passed to are reduced so that the ingots become more thinner and thinner and the necessary shape or size can be obtained.

So the next type of mechanical treatment s called drawing. Drawing is nothing but its ductility of the capability of a metal to be drawn into sheets or wires. This operation is carried out to reduce the cross section and increase the length proportionally. So in case of wires in case of wires the cross section is reduced extremely low and the length is proportionally increased. The metal is drawn through dies or specially shaped tools. The drawing is continued till wire of required diameter or cross-section is obtained. This process is used to prepare wires and rods. So this is called as ductility drawing of a metal is called as ductilitic capability. Wired drawing gives good internal working to a metal but of course is limited to the peculiar forms which can be made by such a process. In fact, the strongest materials ever produced has been made by a suitable combination of annealing and drawings. We'll be looking what annealing is, one of the strongest made is actually made by a combination of mechanical treatments that being annealing and drawings.

So the next thing is Forging. Forging is done something for a very long time and is also very viable today and is very effective too. It gives one of the common forms of mechanical treatment of steel. So this operation is carried out by repeated blows under a power hammer or a press. So it's a combination of actually two mechanical treatment process. You first hammer a particular metal or material and press it. The metal is heated above the critical temperature range. It is then placed on anvil and subjected to blows of hammer. So you do two to three process at the same time of mechanical treatment. This process increases the density and improves grains size of metal. Other than that it also the riveting belongs to forging operations. So we've talked about how riveting is important, the steel structure in a in the Chrysler building in New York is supposed to have steel of riveted character so this is done by forging operations. The process is used for manufacture of bolts, camps, etc. So with that we saw the various market forms I mean the mechanical treatment of steel.

**Market forms of steel**

We'll now be moving onto market forms of steel. So the various mechanical treatment of steel has led to the formation of different types of steel which can be used in market today.

So there are various types of steel that are used, steel is actually an alloy in itself the addition of carbon to iron makes it steel, similarly other elements can also be added to steel to make it better alloy, enhance its property be suitable for various other purposes. So there are over 3,500 different grades of steel, encompassing unique physical, chemical, and environmental properties as I mentioned. In essence, steel is composed of iron and carbon, although it is the amount of carbon, as well as the level of impurities and additional alloying elements that determine the properties of each steel. As I mentioned we talk about steel the amount of carbon in it so the amount of carbon can be from anywhere from 1% to 50% and this is what that actually decides the physical characteristics and also the chemical characteristics of steel and how it performs as a material. The carbon content in steel can range from 0.1-1.5%, but the most widely used grades of steel contain only 0.1-0.25% carbon. So this that we are talking about the steel in use. When you mention steel the steel that we use is used in common is one that contains carbon which has 0.1- 1.5% or most widely used steel ha 0.1-0.25% to be exact in terms of carbon.

Different types of steel are produced according to the properties required for their application, so the purpose that a particular building material or in this case steel has to solve besides what type of character it has to have and the properties need to be varied accordingly so that decides the type steel that need to be used. So various grading systems are used to distinguish steels based on these properties. Steel can be broadly categorized into four groups based on their chemical compositions, they can be carbon steels obviously we are talking about the level of carbon that is being introduced in steels, the alloy steels the use of other elements in addition to carbon in steel to make it suitable to various purposes, stainless steel which is rather ideal form or perfect form of steel and other Tool steels.

So we'll look briefly about the different market forms of steel so now we're talking about carbon steels the most widely used and recently more innovatively used form of steel. So Carbon steel can be segregated into three main categories, Low carbon steels which is basically nothing but steel, Medium carbon steel and High carbon steel. So Low carbon steel typically contain 0.04% to 0.3 % carbon content. Its one of the largest groups of carbon steel. It covers a great diversity of shoes from Flat sheet to Structural beams. So this is nothing but almost steel, this is called as mild steel this is used to make felt sheets and structural beams so this is what low carbon steel is. Depending on the desired properties needed, other elements are added or increased. For example, for increasing the Drawing Quality the carbon level is kept low and Aluminum is added. So as I said the carbon that is added enhances the properties and it can be varied in order to suit various purposes and for example you can talk about how steel can be made more suitable to drawing or ductility, this can be done by keeping the carbon level low and by adding aluminum to a greater extent. We now move on to Medium carbon steel, typically has a carbon range of 0.3% to 0.6% and a manganese content ranging from .6% to 1.65%. So we'll be talking about structure steel in many cases and structure steel is nothing but carbon and manganese put together, so mild carbon steel is something that is extensively used to make structure steel. This product is more stronger than ow carbon steel, and it is more difficult to form, weld and cut. So that makes it ideal for structural purposes so Medium carbon steels are quite often hardened and tempered using heat treatment. So apart from it being varied in terms of its properties its also further hardened and tempered. So High carbon steel also known as "carbon tool steel" it typically has a carbon range between 0.6% to 1.5%. High carbon steel is very difficult to cut, bend and weld. Once treated it becomes extremely hard and brittle. So that's the characteristic of high carbon steel.

We'll now move on to alloy steels we talked about various elements that can be added to steel to enhance its properties further. Alloy steels contain alloying elements e.g. manganese, silicon, nickel, titanium etc. in varying proportions in order to manipulate the steel's properties, such as its hardenability, corrosion resistance, strength, formability, weldability and its ductility. So all these can be varied with the addition of various elements to it. Application for alloy steel include pipelines, auto parts, transformers, power generators and electric motors. So its alloy steel adding various elements to steel to make it better. We'll not talk about stainless steel which is the ideal form of steel and is used very extensively today, so stainless steel generally contain between 10-20% chromium as the main alloying element and are valued for high corrosion resistance. With over 11% chromium, steel is about 200 times more resistant to corrosion than mild steel. So now you can compare why steel and stainless steel have different contrast, stainless steel is considered the most ideal version of steel because it is 200 times more resistant to corrosion makes it completely indestructible and favorable in terms of use. These steels can further be divided into three groups based on their crystalline structure. Austenitic: Austenitic steels are non-magnetic and non-treatable and generally contain 18% chromium 8% nickel

and less than 08% carbon. So these steel form the largest portion of the global stainless steel market and are often used in food processing equipment. So stainless steel has takenextremely used a lot in various industries so now we're looking at the various types of stainless steel. Ferritic: as the name mention adds more iron to it so has trace amount of nickel, 12-17% of chromium and less than 1% carbon .1% carbon along with other alloying elements such as molybdenum, aluminum or titanium. These magnetic steels cannot be hardened with heat treatment, but can be strengthened by cold working. So you see the characteristic and character changes as and when the materials are added, next we move on to Martensitic: Martensitic steel contain 11-17% chromium, less than.4% nickel and up to 1.2% carbon, so these magnetic and heat treatable steels are used in knives, cutting tools, as well as dental and surgical equipment. So this is an example of a building made completely in stainless steel, the external envelope is totally made from stainless steel, this is extremely resistant to corrosion it is weather resistant it is easy to maintain and it can be very durable and long lasting so it has become a very important material in architecture and building usage, besides that lot of railings and interior applications, staircase etc. are made from stainless steel these days. Finally, Tool steels contain tungsten, molybdenum, cobalt and vanadium in varying quantities to increase heat resistance and durability, making them ideal for cutting and drilling equipment. So from a material being directly used to building it can be used to make other materials so such in the case of stainless steel. Steel products can also be divided by their shapes they can be Long/Tubular products it can be Flat products it can be Other products such as valves, fittings or small nails etc. So Long products commonly used in automotive and construction sectors, so the long tubes, structural frameworks made from tubular steel products, so Flat products in automotive parts so sheets are basically flat products so the drawing ability or the malleability of these products can be put to application in appliances, packaging, ship building and also construction. So the other products as I said valves, fittings, and flanges are mainly used as piping materials. So building services is also an important part of architecture and stainless steel , steel find a lot of application in them.

**Fire Protection**

So we'll now move on to fire protection. As I said when a particular material is used extensively it also has to responsible in terms of various concern of which fire protection is an important factor. So fire protection in a building is nothing but the ability of a particular material to be able to withstand for greater amount of time until the fire or the source of fire has been cut out. So when you talk about a material being fire resistant or fire retardant or fire proof it doesn't the fire is totally it cannot totally affect the material, what happens is its able to contain it to an extent until other measures can be tried, so that's what measures the fire protection of a metal. So in this case fire protection of steel we are talking about Active fire protection, which can include manual or automatic fire detection and fire suppression. So we're looking at types of fire protection in a building, so Passive fire protection, which includes compartmentalization of the overall building through the use of fire resistance rated walls and floors. Measures to prevent or slows the spread of fire from the room of fire origin to other building spaces. Fire prevention includes minimizing ignition sources, as well as educating the occupants and operators. So as far as steel or the material are concerned the building materials are concerned fire protection canbe applied only in the form of passive fire protection so active fire protection means dousing the fire off using the water or sand to cut off and Fire prevention means educating and cutting ignition sources, but building materials can be addressed in terms of fire protection only as passive means, so that's how we're going to be looking at it. Passive fire protection materials insulate steel

structures from the effects of high temperatures that may be generated in fire. So what happens is steel reaches a really high temperature becomes soft becomes very malleable and it gives way so this has to be prevented so what happens is basic science basic understanding of how to make steel fire protective is to add a coating or is to add other materials to make it last longer during a fire. They can be divided into two types non-reactive, of which the most common types are boards and sprays and reactive, of which thin film intumescent coatings are the best example. So some interesting ways of how a fire protection can be applied at least in the case of steel by incorporating a proprietary fire protection system, the ability of the structure to resist fire will be greatly enhanced dependent upon the particular system chosen. So these different types of fire protection like non-reactive can be combined together to create a fire system which is fool proof in all ways. So now we'll be looking at various types of passive fire protection that can be applied to steel. Cementitious fire spray is a fast and efficient method of providing up to 240 minutes' fire protection. So I said fire protection is the number of minutes or the number of hours that can extend from the fire destroying the structure wholly, so cementitious fire spray offers 240 minutes' used in the commercial, petro-chemical and tunnel markets, cementitious fire sprays withstand impact and abrasion, yet remain flexible to accept design changes without incurring major cost and time delays. So apart from method of fire protection to be able to retard fire it also can be flexible in terms of design and application in direct building industry etc., so that also comes into account in better use of fire retardant. It may be applied within environments where limited exposure to the elements is likely throughout the building phase of the project. So there are nooks and corners in building places which are not easily accessible throughout the construction out throughout the building usage so such spaces can be sprayed with cementitious fire spray. They can also be used for application to steel and concrete frames, metal floors or roof decks. So direct steel structures, steel frames etc. can be used to become fire retardant by using cementitious spray in their cases, so this is how they spray so what happens is they spray cementitious content on to the steel frame structure which makes it fire retardant and gives up to 240 minutes' of fire protection. Next we move onto boarded system, boarded system is nothing but having a skeletal steel framework or metal framework covered by a system of boards such that heat or fire does or pass through the board and reach the metal. So boarded fire protection systems offer a non-combustible and cost efficient method of providing up to 240 minutes' this also provides a lot of minutes. As the original means od affording fire protection, this method has seen major development in the types of boards available today. So board fire protection system can be durable, resistant to water and beneficial to acoustic performance. So apart from being fire resistant the fact that we could use boards cut off totally and seal the acoustic purposes it can serve acoustic insulation as well. Certain fire board systems are able to accept decorative applications; such as paint or plaster. So apart from being able to retard fire it can also have design applications having added aesthetic value enhances its use, so as I said those are basic steel frameworks or a skeletal framework inside over which boards are said to be covered. So Intumescent System is the next system is more reactive form when you directly face a steel to a fire accident it comes with an interesting reaction we'll be looking at that. So a thin film applied Intumescent paint is a fast method of providing up to 120 minutes' fire protection to structural steelwork. So we locked at how 240 minutes of fire protection was available but that was the case of non-reactive cases but here when fire is directly accustomed to the steel it can provide up to 120 fire protection. Intumescent coatings provide an appearance similar to that of paint, with basic to high gloss finishes now available, so aesthetically too you can choose it. At ambient temperatures intumescent paint systems remains stable. However, in afire condition, the increase in temperature activates a chemical reaction that's what we saw in the image, so the increase

in temperature activates a chemical reaction which then causes the intumescent coating to expand many times its original thickness, so this is a demonstration of happens, the steel structure or frame is applied with intumescent paint and when its exposed to fire what happens is it forms a charring product which thickens and extends forming larger volume space and thus it retard fire from approaching the steel structure, so it expands many times than its original thickness this expansion provides an insulating foam like coating or char basically its just char and ash that provides fire protection to the steel work.

**Corrosion**

We looked at various ways in which steel can be protected now we'll look at various ways in which steel can be corroded. Corrosion is the deterioration of a metal as a result of chemical reactions between it and the surrounding environment. Both the type of metal and the environmental conditions, particularly what gases that are in contact with the metal, determine the form and rate of deterioration. So what happens is when a metal is particularly exposed to the environment the various gases or the chemical changes that can happen to it is called as corrosion. So basically there are three theories of corrosion of how it takes place the acid theory, The Dry or Chemical corrosion theory and the galvanic or electrochemical theory, so these are various ways in which corrosion can affect a particular metal. We will look in Acid theory first; this theory suggest that corrosion of a metal is due to the presence of acid surrounding it. Air can be acidic in nature sometimes, sometimes rain that comes over or the various processes the particular space go through can have acids in them so this way of corroding a particular metal is called acid theory. So Chemically corrosion on the surface of the metal is due to direct reaction of atmospheric gases, so we talked about dry or chemical corrosion this is nothing but the reaction of the metal surface directly to the gases present in air like oxygen, halogens, oxides of Sulphur, oxides of nitrogen etc., there are some cases in which metals like copper use these oxides to form protective casings around them so corrosion can also be sometimes useful. Electrochemical corrosion is a common type of corrosion of metal in aqueous corrosive environment, so when some metals are exposed to liquids or electrochemical the corrosion that can dissolve from that is called electrochemical corrosion. This type of corrosion occurs when the metal comes in contact with a conducting liquid so when two dissimilar metals are immersed or dipped partly in a solution this could happen. So corrosion prevention techniques can be generally classified into six groups so you can study in detail about this also.