

Course on Design of Steel Structures
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Mod01 lecture 01
Introduction to Limit State Design of Steel Structures

I welcome to the limit state design of steel structure class. The limit state design of steel structure has been introduced in our Indian code in 2007, before that we use to design the steel structure by the use of (0:38) working this method and from 2007 onwards, the code provision has been changed and in 2007, the IS 800-2007 has been published where the entire code has been discussed on the basis of limit state design method.

Now coming to this course actually, this today I will discuss about the probable content of the course, which I am going to cover in next 60 lectures and the what are the books you can follow that I will inform and what are the code require for learning this course, all also will be told today and also I will show you some steel rolled section. What are their property have the parameters are vary and means how the parameters are considered? Which parameters are considered? Which are given in the IS handbook that SP-6 that also I will just give you touch on that, right.

Now coming to the limit state design of steel structure, one thing we can say that nowadays, in every city or every country whenever you see some (1:59). These are mostly built with the steel. Steel has lot of advantages which I will come later, and because of its advantageous properties (we) the designer prefer for designing the structure with the steel and steel structures are means steel are massively used particularly in bridge structure and also in transmission tower, refinery well structure, in sometimes some water tank also are made of steel structure, some high (2:37) buildings, many industrial buildings, (2:41) all are made of steel structure and steel you know that, it is much stronger than compared to the conventional constructional material like concrete compared to its high means strength to weight, this is very high, means its weight its very less and strength is very high. It is much ductile compared to concrete and, because of its advantages (3:08) for its means properties.

Designer prefers steel structure, though it is costly. So if we design properly in a cost effective way the cost can be minimized without compromising the safety. therefore we need to know the design procedure properly and may be in later by knowing the design procedure

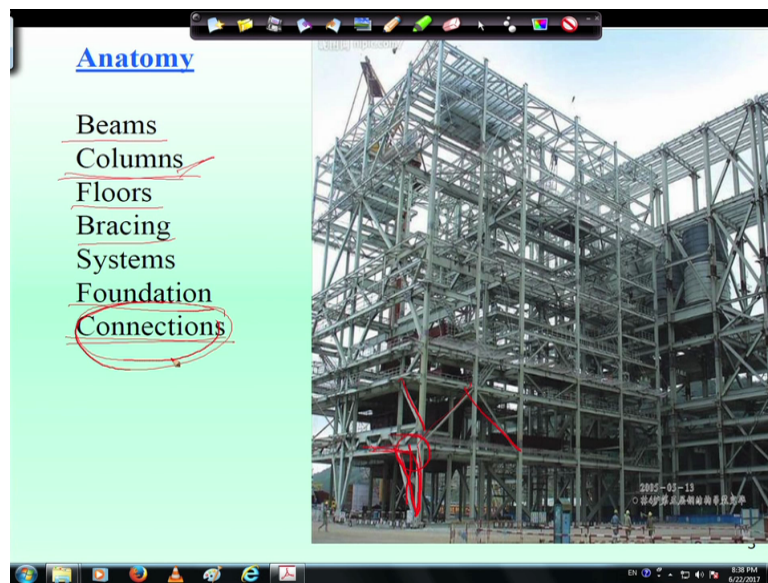
we can make, computer code we can generate some computer algorithm by the use of matlab or any other standard language like C language, C plus plus, java or we can use excel sheet also, then in steel design you will see, when we are going to design we have to iterate (())(3:53) it we need to iterate (())(3:55) it, the design process means we will assume certain member with certain dimensions and we will check certain checks from limit state point of view, from ultimate strength point of view, from serviceability criteria point of view.

We will check certain steps and if we see the checks are not satisfying then we have to increase the size and if we see it is satisfying then we can go for this particular section, but what happens that while we do for iteration.

In case of limit state design, there are lot of procedures means procedures or calculations are there. So it is very difficult to do by hand manual calculation. So if you can develop computer algorithm or if you can develop an excel sheet then just by putting the value you can check, whether it is okay or not and in some cases we have seen that when designer is saying that the assume section is okay then they have simply going with that section, but that is not economic, because may be with some larger section the same with same loading it may be safe.

So we must go for the larger section, so sometime designer does not want, because lot of calculations have to be done. It is a tedious process. So I will suggest you that if you know the design algorithm if you understand the design process of a particular member then you make a customize program at your own requirement and then go for the, this program for design of the section and in that way you can make that design optimized, economic and cost effective.

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Now coming to the anatomy of the structure we will see that any steel structures are having these types of members, like one is beam. Beam is basically a flexural member where the flexural come into picture. So we need to know the design of a flexural member of the beam, then it will come the column. Column also takes the compressive load along with that certain eccentric load also it takes care, so sometimes moment also come into picture, that column has to be design accordingly. So we will go through that column.

Floor basically carries the load and that load is transferred to the beam and column, then bracing system is an important system in case of steel structure, because you see here if we see these are the bracings. Bracings has been provided just to increase the load carrying capacity in terms of horizontal load when horizontal load is moved the we can provide certain bracing in certain places so that the system became stronger.

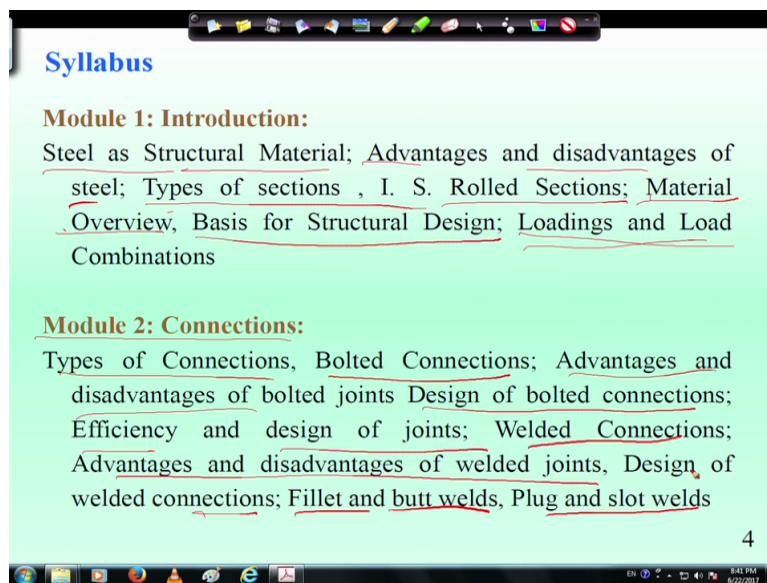
Now all the super structural load are going to the foundation, so we need to know the foundation design also. So there in foundation we will see the slab base, gusset base, base plate and how the load from the super structure has been transferred to the sub-structure by the use of base plate and other members that we will see and another important part we do not generally come across in case of RCC structure that is connection.

these connections is important editions we know the rolled steel sections are available or some other type of sections also can be made available in terms of built up section etcetera, but it need to be joint properly. So joint means basically joining of beam and column beam

and column when you are going to join you have to join either by the use of bolt, rivet or weld connection.

So in fact when I will be going to teach this subject, so first I will discuss about the connection, because if we know connection then we can go the further things and in design means in steel design as a whole (8:22) connection plays a very important role we do not give much importance to the connection, though, but we have to make detailing means I would go I will recommend that when we are going to do design a entire system we have to specially look for the connections and we have to design connections properly, so that load is transfer from one system to another system, one member to another member properly, sometimes moment also has to be transfer sometimes only axial force. So, on the basis of the requirement we have to decide what type of connections will be going for.

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Syllabus

Module 1: Introduction:
Steel as Structural Material; Advantages and disadvantages of steel; Types of sections , I. S. Rolled Sections; Material Overview, Basis for Structural Design; Loadings and Load Combinations

Module 2: Connections:
Types of Connections, Bolted Connections; Advantages and disadvantages of bolted joints Design of bolted connections; Efficiency and design of joints; Welded Connections; Advantages and disadvantages of welded joints, Design of welded connections; Fillet and butt welds, Plug and slot welds

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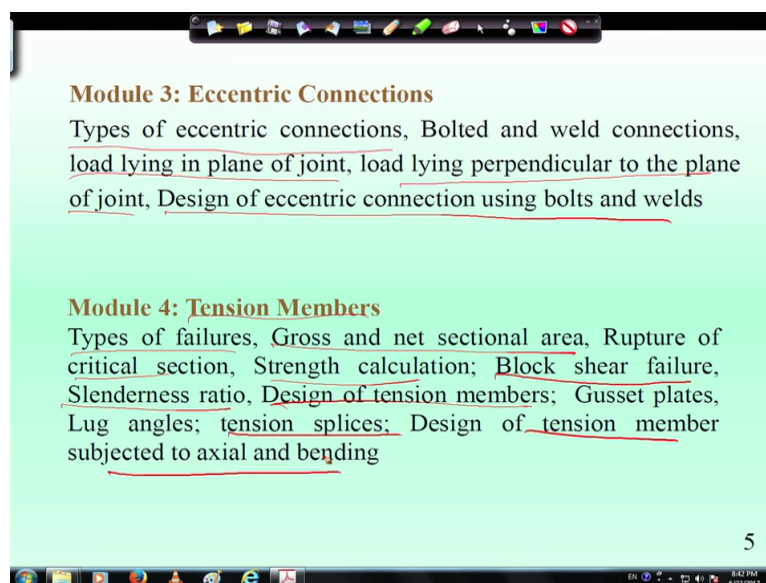
So syllabus which I am going to cover I am briefly discussing, but it is a tentative, because I do not know how much time I will get to finish, so first module will be including the introduction and which we will discuss about steel member means steel material as a structural material and we will discuss its advantages and disadvantages of the steel, because unless we know the disadvantages of steel we will not make use properly.

So we must know the advantages and disadvantages and accordingly which we should try to use that then we will go for different types of sections, I. S. rolled sections which are available in the market those and their properties are given in the code that we will see then we will go for some material overview, means how the steel behaves with increase of load

means how stress strain varies in case of steel and how the chemical properties deep mean how chemical properties means how the mechanical properties are dependent on chemical properties of the steel that we will discuss then basis for structural design will be discuss means what type of structural design we are going for in this course that we will discuss that is the limit state method and what are the basis of design of that structural philosophy that will be discussed and a course loading and load combination

Different types of loads come into picture, those we will be discuss briefly and their combinations then we will come to the module 2 which is comprising (11:00) of connections. So different type of connections we will discuss and in that connection we will discuss about the bolted connections, its advantages and disadvantages, then design of bolted connections, its efficiency and design of joints then welded connections, advantages and disadvantages of welded joints, design of weld connections, fillet weld, butt or group weld, plug and slot weld. So these are the topics probable topics I am going to cover.

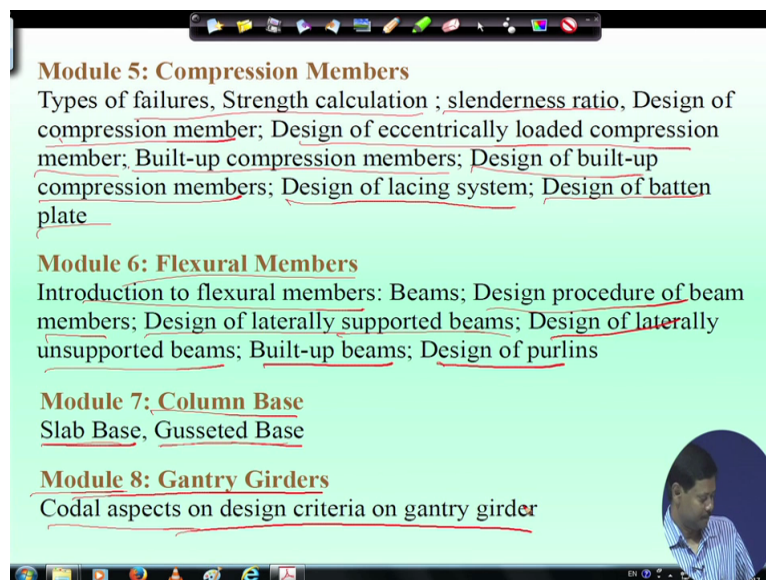
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Then in next module we will discuss about the eccentric connections, because sometimes connections become eccentric in terms of its loading. So different type of eccentric connections are observed, so we will discuss about that then bolt and welded connection with load lying in plane of joint and load lying perpendicular to the plane of joint. Different type of means two type of eccentric and connections are observe one is load lying in plane of joint and load lying perpendicular to the plane of joint.

Then we will discuss about the design of eccentric connection using bolts and weld that means sometimes we will use bolt and we will see how the design procedure is proposed and also same thing for weld connections, and in module 4, we will discuss about the design of tension members. In tension member, we will first come into different type of failures mean in case of tension member what are the failures occurs that we will see then we will find out the gross and net sectional area, then rupture of critical section then strength calculation, block shear failure, then slenderness ratio of the member and then we will come to design of tension members considering all this and then gusset plates, lug angle, tension splices, design of tension members subjected to axial and bending those things will be discussed. So tension member we will means in this module we will cover these aspects.

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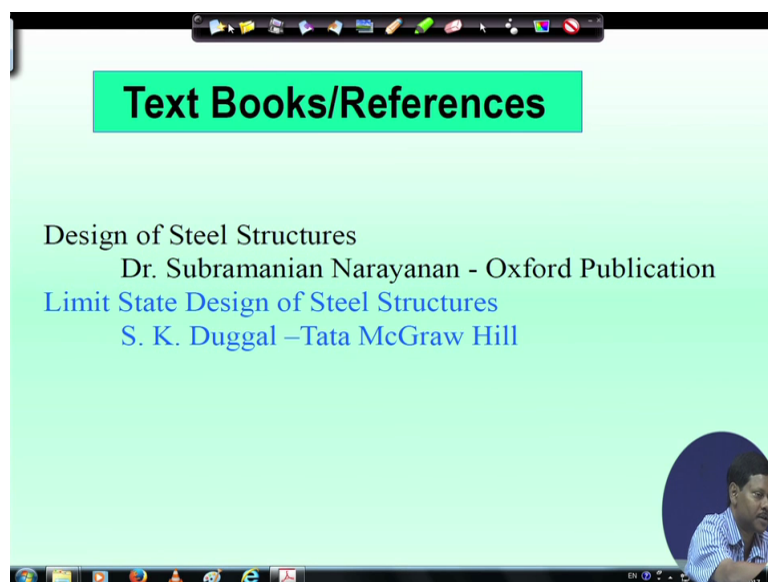
In module 5 we will discuss about the compression member. In compression member, first we will see what are the type of failure occurs in case of compression member and accordingly the strength calculation will discuss and then slenderness ratio of the compression member how to calculate we will find out and then design of the compression member and then design of eccentrically loaded compression member that means when moment also will come into picture then how to design the compression member that will be discuss.

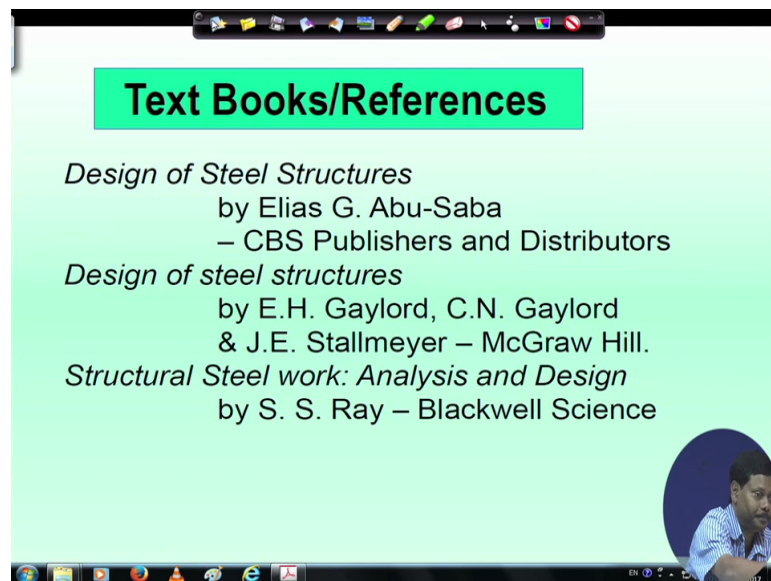
Then built-up compression member means sometimes the rolled steel section is not sufficient for withstanding the huge amount of load. So in that case we will go for built-up compression member and that is design procedure also will be discussed for the built-up compression member then for built-up compression member we need to add the lacing systems. So design of lacing system and design of batten plates will also be discussed in this module.

And in module 6 we will discuss about the flexural member which is called basically beam. So we will give you some introduction to flexural member and then design procedure of beam and beam will be basically two types, one is design of laterally supported beam and laterally un-supported beam. So both the cases, design procedure will be discussed considering laterally supported and laterally un-supported beam and also will be discuss about the built-up beams and design of purlins also will be introduced in this module.

Then we will come to column base, column base we will be discuss basically base slab **and** this gusseted base. So slab base and gusseted base which are **w** the element through which the super structure load will be coming to the soil to the sub-structure. So design of the gusseted base and slab base along with base plate will be discussed here and if we get time then we will discuss about the gantry girder, because in steel structure gantry girder is an important component , which we need to know and design and the codal aspects are available on design criteria on gantry girder. So in last module we will discuss about the design aspects of gantry girder mean various type of loads will be there. So what are the loads coming into gantry girder and how to design the gantry girder will be discussed.

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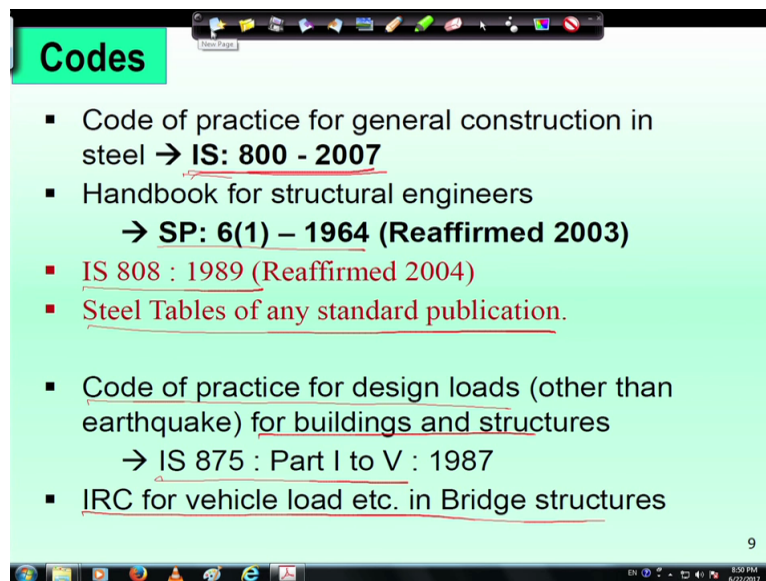


Now I would suggest to follow along with my lecture these two books. These books are very well written one book is design of steel structure written by Dr. Subramanian Narayanan who has directly involved with the development of I. S. 800 2007 code. So he has written this book which is very exostively written and well means well documented and another book also you can follow that is written by S. K. Duggal, it is Tata McGraw Hill publication limit state design of steel structure and the first book was published by Oxford publication.

So there than these two books you can follow some other books also if you want , but I have seen many books are available in which design calculations are not given properly, but in these two books will means you can follow and we can get properly the design calculation and procedures and very well documented in a simplified manner it is written, so you can follow this, you can go for some reference also like design of steel structure by Elias Abu-Saba, this is CBS publication this also you can use as a reference book.

Then design of steel structure by E. H. Gaylord at all by McGraw Hill and structural steel work by S. S. Ray Blackwell science. So as a reference books you can follow; however I will suggest you to at least follow one text book which has been suggested in earlier in earlier slide that si either Dr. subramananyns book or S. K. Duggals book.

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Codes

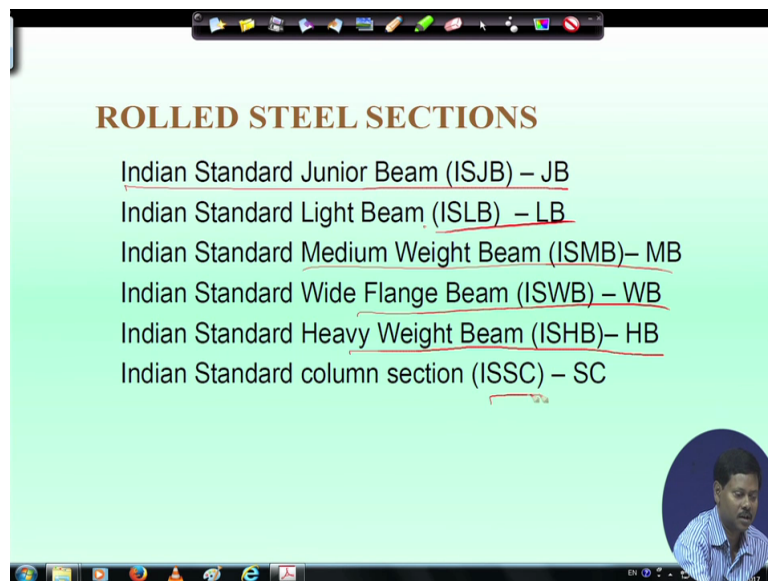
- Code of practice for general construction in steel → **IS: 800 - 2007**
- Handbook for structural engineers
→ **SP: 6(1) – 1964 (Reaffirmed 2003)**
- **IS 808 : 1989 (Reaffirmed 2004)**
- **Steel Tables of any standard publication.**
- Code of practice for design loads (other than earthquake) for buildings and structures
→ **IS 875 : Part I to V : 1987**
- **IRC for vehicle load etc. in Bridge structures**

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Now these codes are required while we learn the design of steel structure, first is that earlier code words IS: 800, 1984 which is based on working stress method. Now the code provision has been changed and in IS 800-2007, the code of practice for general construction in steel has been given in which the limit state design method has been followed. So when you follow my lecture I will suggest you to see to with (())(18:52) this code, because a lot of code provisions are there, which has to be followed and while listening my lecture if you follow the codes and if you open the code also at the same time it will be easier to understand the lecture and it is easier to understand means follow the code also and we have a handbook that is SP 6(1)-1964 handbook for structural engineers where the Indian steel rolled section properties are given.

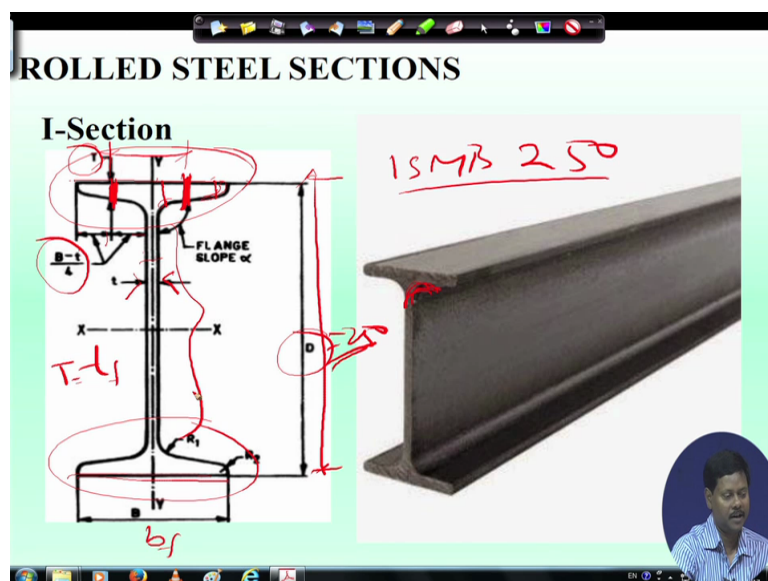
All the standard rolled section properties like ISMB means I section, channel section, T section, angle sections, so all the rolled sections properties are given in that IS handbook. So we should follow that also and also we can follow this IS 808-1989 where certain properties are given certain properties of steel load section and also you can use steel table of any standard publication where the properties are given, right. Other than that I will suggest you to follow this code of practice for design loads other than earthquake for building and structure that is IS 875-part I to part V I will come with this code in details later and also IRC code vehicle load in bridge structure may be useful apart from this for seismic consideration (())(20:22) IS 1893-2002 also will be you can use.

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Now coming to rolled steel section, I have told that different type of rolled sections are available in the market and their properties are given in IS handbook in SP-6, so like here I have shown that indian standard junior beam which is termed as JB also, sorry. So Indian standard junior beam ISJB, Indian standard light beam ISLB or LB and Indian standard medium weight beam that is available, Indian standard wide flange beam. So different type of I sections are available in the code. Indian standard heavy weight beam ISHB, Indian standard column section SC like this you will get like.

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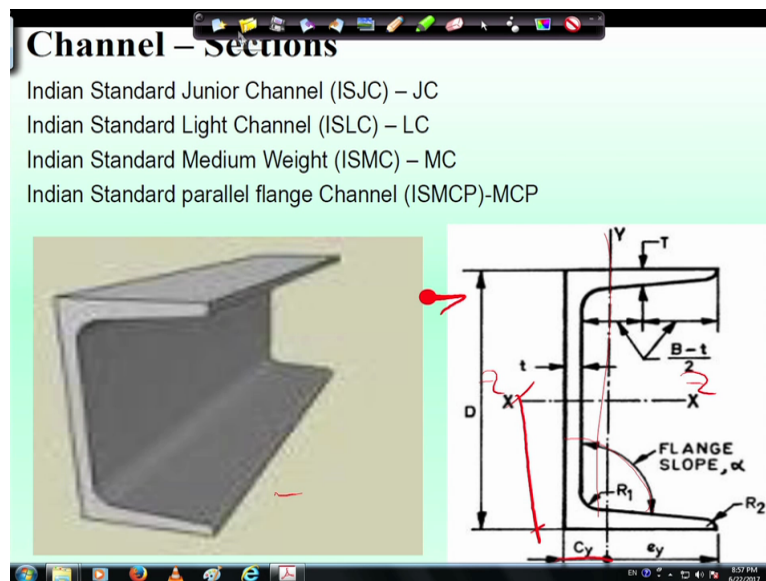
Now say I section what I was discuss that I will discussing that ISMB, ISLV, ISJB so in all this beam section or I section , this looks like this, if you see it is we have a slop here and we have curve here so that the stress concentration does not develop here and also here also you have curve. Now the overall depth of I section is called D, in the SP-6 the properties of I sections are given, in terms of say suppose if you say ISMB 250 that means it will effect to a particular I section of medium beam ISMB, the 250 means the overall depth of the will be 250, right. So D will be 250 overall depth.

Now if this 250 depth of beam is (22:46) means if you select then automatically you will find what will be the width of the flange. This portion is called flange and this width of flange is called b and sometimes we call bf also, b or bf and this is the portion of OF and this OF thickness is called t regeneration tw, tw you have to call.

Now what will be the thickness of flange? Thickness of flange vary from here to here if you see here thickness of flange is much higher than this place. So thickness of flange is measure at b minus t by 4 distance that means this is total b, this is t, so b minus t by 2 is this distance and middle of that is the b minus t by 4, t is the tw thickness of width (23:43), so at that position we find the thickness of the flange either capital T we mention as T of tf also we call tf also.

So if you see in the SP-6 the properties of I section then can find out suppose if it is ISMB 250 then its depth is 250, its width, its cross sectional area and the geometrical properties everything is mentioned there not only the geometrical properties, but also the say suppose I_{xx} I_{yy} that means moment of inertia about xx abut yy and then we can find out R_{xx} means radius of direction about x direction about y direction, so all the details then z, section modulus, Z_e , Z_p , those things also you will find out then what will be that gauge distance between these two means where the bolt bolt or rivet will be placed. So that gauge distance also standard for particular section. So all the relevant properties you can find pout from that code, right.

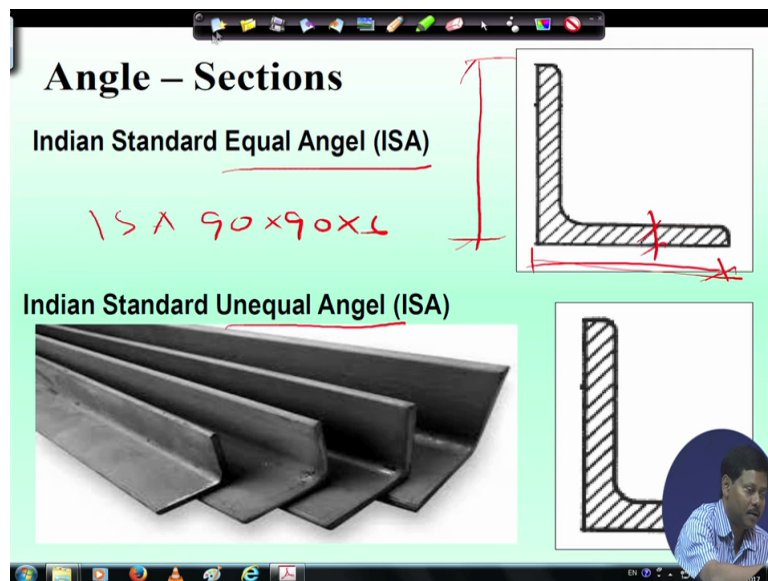
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So this is another section which is called as channel section. This channel section are mainly used for column, this channel sections are used, so Indian standard junior channel ISJC. Similarly, ISLC Indian standard light channel, Indian standard medium weight channel ISMC like these channel sections are available in the code also. So here also ISMC 400 means the depth D will be 400, ISMC 400 means the depth will be 400 overall depth will be 400. So once depth 400 other properties are given in the SP-6.

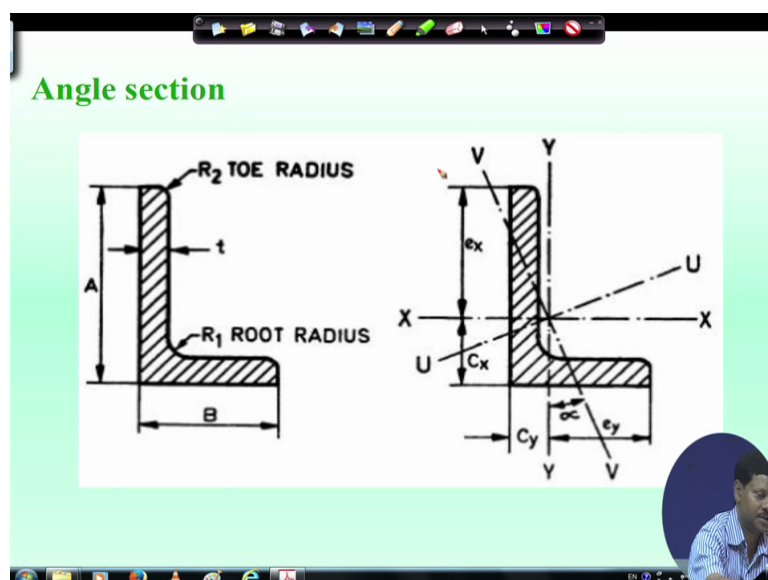
So this is the bf this is called bf width of the flange bf and this is tf or T that is b minus t by 2 at B minus t by 2 that is defined and T is basically t_w thickness of web, then what will be the radius of curvature here means R_1 and this is R_2 that also are standard that is given it. Then C_{xx} C_{yy} that also C_{xx} means this is C_{yy} and this is C_{yy} and this is means D by 2, right. and so these are the properties flange slop, α will be this, so these are the standard property which are given in the code and it looks something like this and in the code means actually in place of XX it is written ZZ means I_{zz} R_{zz} and this important yy this is how it will be consider.

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This is angle section, angle sections are of 2 types, one is Indian standard equal angle and another is Indian standard unequal angles. Equal angle means its leg is leg length will be same. Here Indian standard equal angle, the both the leg length will be same but if it is unequal then it is unequal angle. So standard writing is ISA 90 by 90 by 6 that means the length of the leg is 90 in this also it is 90 and thickness of the leg is 6 mm and of course also we find out all other properties of the angle section which is shown here.

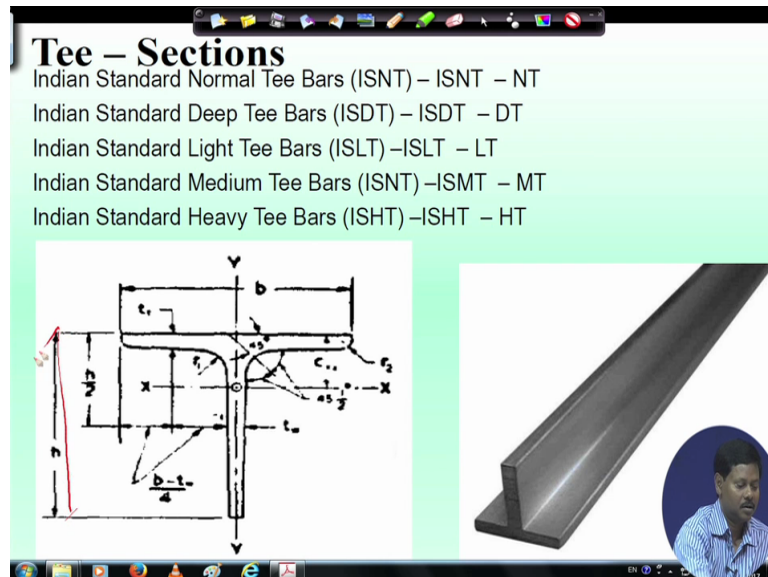
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So if you see in the codal provisions angle sections are given like this is root radius R_1 this is toe radius R_2 , these are also standard and C_{xx} C_{yy} that means center of gravity in x and y then what will be the I_{xx} I_{yy} I_{uv} means in major axis minor axis I_{bb} , so R_{xx} R_{yy} R_{bb}

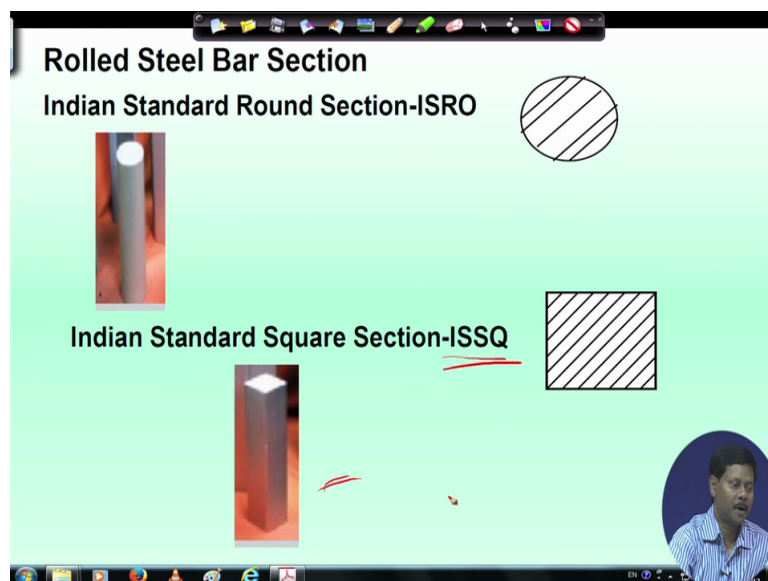
RUU all these properties are given, which will be required for calculation of different stresses on the section. So for designing of the member using angle section we need different properties geometrical property which are available in the SP-6.

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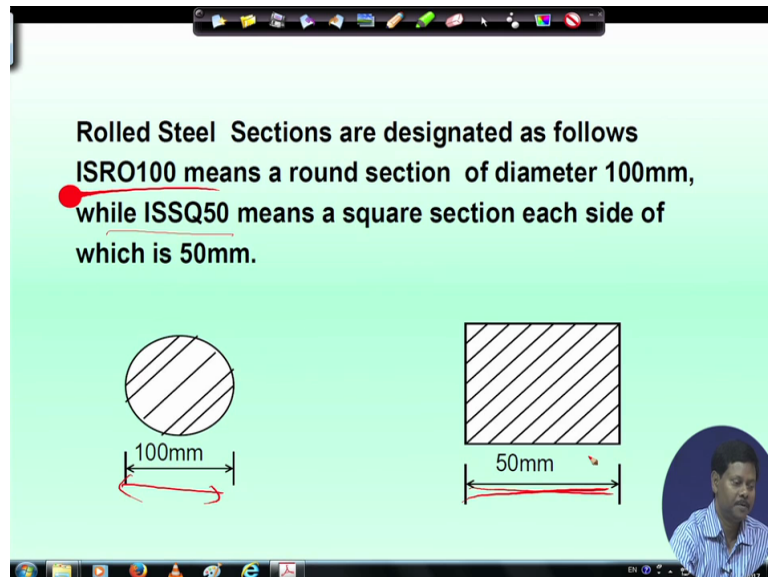
This is another section which is called section, Indian standard normal Tee section and here also in case of T section, the total h is the depth and other details I am not going in details you can find out in the code.

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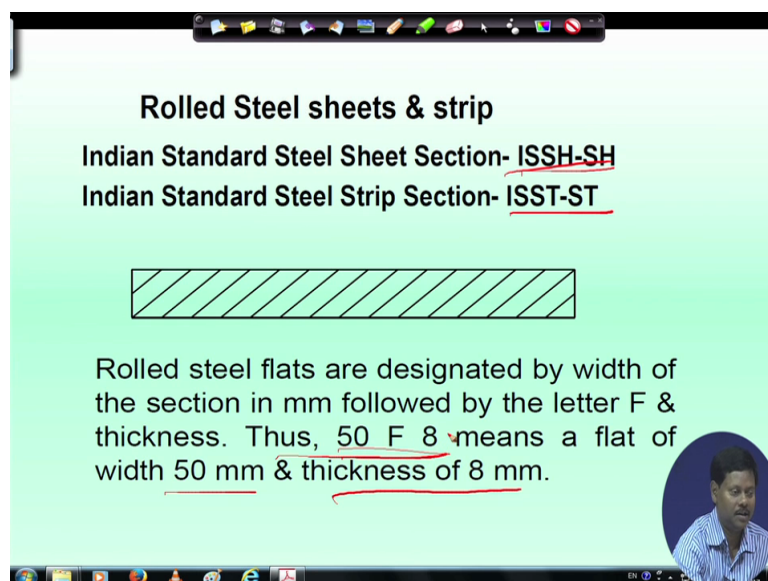
This is rolled steel bar, Indian standard round section ISRO is called and Indian standard square section. This is square bar, so this type of bars are also available and which can be used for design of different type of members.

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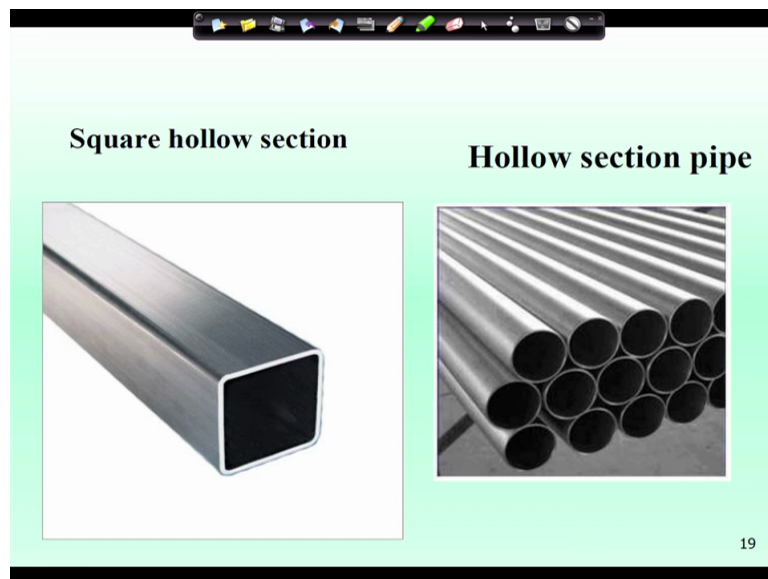
Then suppose, ISRO 100, in rolled steel section if you see ISRO100 that means it is a round section of diameter 100 round section of diameter 100, again ISSQ50 means it is a square section of each side 50 mm ISSQ 50 means this is square section of 50 mm. So this is how it is designated.

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Then rolled steel sheet and strips are also used, those are also available Indian standards steel sheet section Indian standard steel sheet section and Indian standards steel strip section, okay. So if actually if we write 50 FT that means a flat of 50 meter 50 millimeter width and 8 mm thickness are used. So this is how letter F means width and sorry, this thickness and width are defined in this way, 50 F 8.

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Then square hollow section this also are used. So this square hollow section and hollow pipe sections are also used in design of steel members. So in this first lecture what we could see is that Indian rolled sections are available steel rolled sections are available and its geometrical properties are given in SP-6 which will be frequently used for design of structural members, right. So with this I will have to conclude today's lecture, next day we will discuss about the material properties of the steel and its advantages and other details, thank you.