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Course
On Reinforced Concrete Road Bridges

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Lecture 06: Working Stress Method

Hello everybody today we shall start on design principles of reinforced concrete elements structural elements that we shall start today, last few classes we have given general idea on bridge engineering different aspects of bridge engineering, different types of bridges and then we have discussed one how to decide that carriage with how to decide that width of the footpath like that now today we shall go for the design principles of reinforce complete structures our basic object of this particular course to do the design so that you will be able to design after complete compression of this course.

That is our whole idea and what we have decided today here this is lecture of open our duration and.

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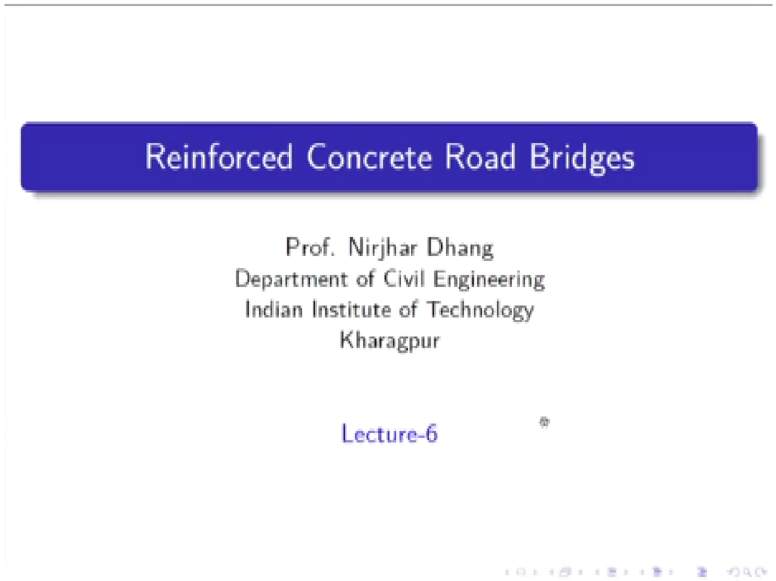

And that one we are considering this particular one lecture 6.

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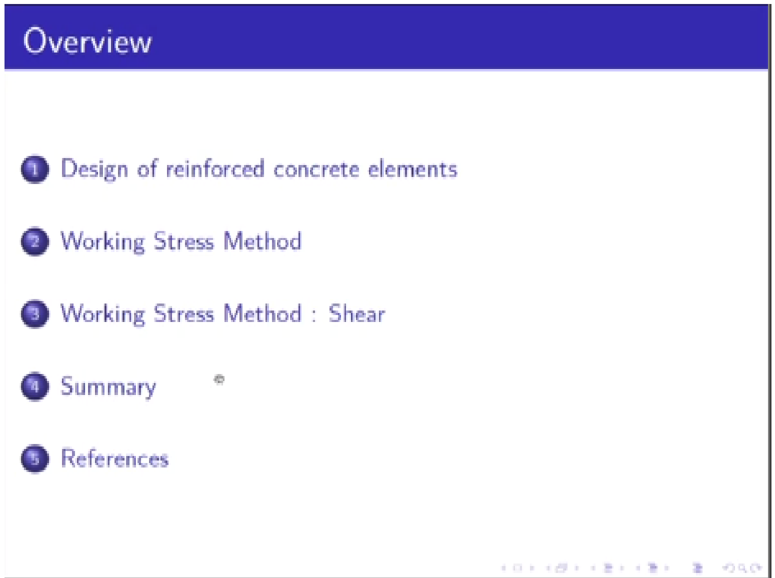

And then we shall consider the general principles of design of reinforced concrete elements, working stress method, working stress method for Shear then summary and references, so that is our over view that we shall consider this is the first part, so we shall try to complete this is one in three upper in our module one that working stress method.

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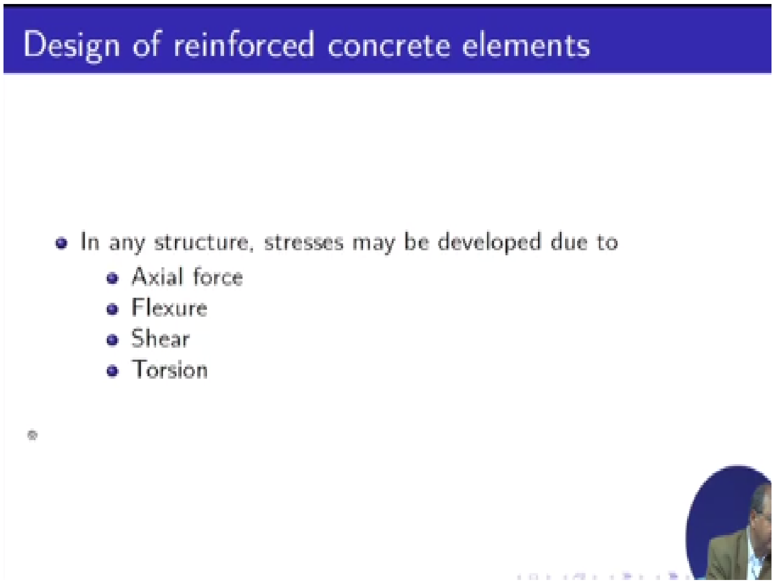

And next one we shall consider limit state method, now if you really see that any structure you are having the stress may be into either Axial force, flexure, Shear and Torsion or it is a combination if you see the structures for Bheams then you will find out for Bheem their mainly it is governed by bending and Shear if you consider slab there you will find out it is mainly governed by bending only, or else column type of structures there we will find out that Axial force and bending Torsion generally we do not directly we cannot go for design whether we take the effect of torsion in bending and in Shear so this is our objective that we can find out here.

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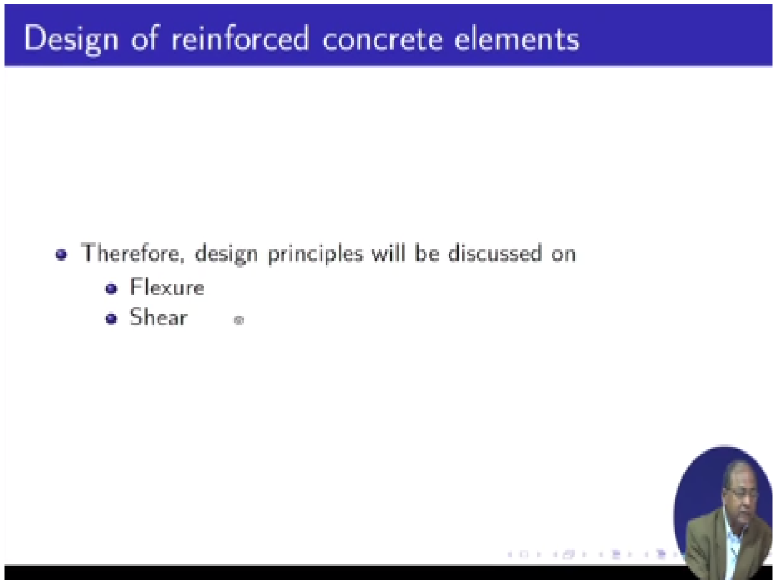

Now considering that a shear out of this four only we are considering the super structure the flexure and shear, so our main focus in this particular class that will be on flexure and shear how to design for that, so we have discuss one flexure and shear only and.

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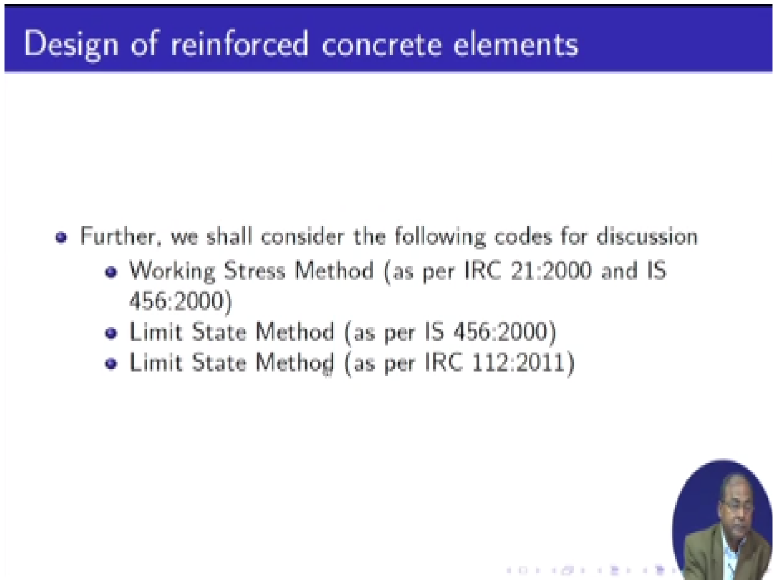

And this is not the course of reinforced concrete design but we require that basic principles and design methodology to go for this design so that is why we have taken that 112 codes that first one IRC 21:2000 and also we are taking IS 456: 2000 our basic objective to know the difference and to know that how far actually differs from one particular code to another code that is our another objective here, next one we shall consider that on a limit state method as per IS 456:2000 and limit state method as per IRC 112 2011 this particular one that which we can follow.

So here also we are having working stress method also that IRC 21 that watch in that also available here but mainly we shall focus on limit state method.

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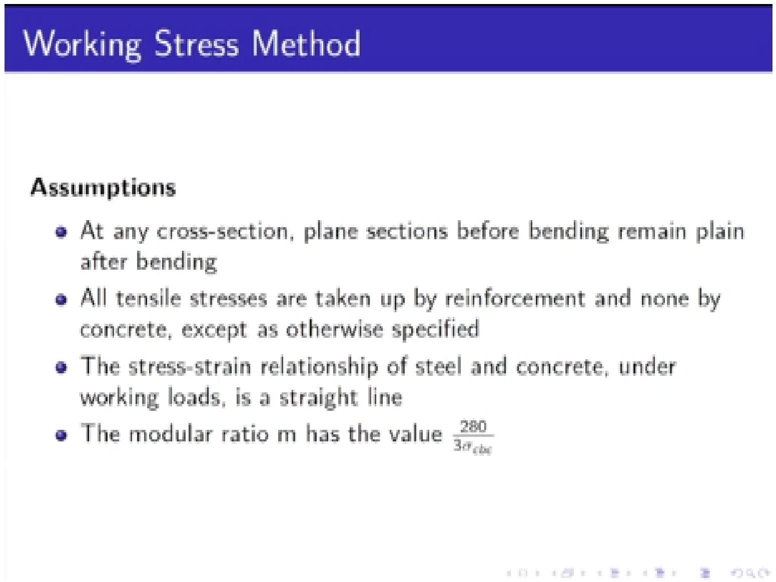

So let us consider that working stress method that let us find out for any method which we have certain assumptions, so what are those assumptions here that let us find out that first let me make it and that we shall discuss at any cross section plane sections before bending remain plain after bending, this is the fundamental assumption and possibly you learned this one either in first year or second year of your B.Tech course in either in strengthen materials or mechanic sub solids and if it is combining in your mechanics.

That is part of system per materials they are in the first bending equation let us assumption and next one all tensile stresses are taken up by reinforcement and none by concrete except as otherwise specified that if it is not specified the we shall not consider in that tension in concrete because the concretes tensile in concrete that one we can say that which is compare that is almost 10 % of the compressive one you can consider, so that is why can neglect that particular portion and compared to the amount taken by the steel that one also be negligible even if you consider and that is why we shall not consider.

And further the section we consider this one is cracked section we shall come to that concrete cracked section that for concrete, so that is why we can we assume that concrete will not taken it the stress strain relationship of steel and concrete under workloads is a straight line this is also another important one because this one and that particular one we are considering the a tensile cross that one this one for the strain and this is for the stress strain car that means we are not going to that were already we illustrated.

Now modular ratio that modular is electricity or steel and modulus of electricity of concrete as we can definitely we can find out for steel you can find out that modular for but concrete it is very difficult to come to a conclusion that what exactly the value, so that is why it is generally very difficult to find out easy that was a industries about concrete in that case what we do we find out that one in a direct manner that modular ration m which will be 280/ 3σ cbc I mean interesting part which are consider this σcbc.

That I shall come that please note down the 3σcbc and please note down this one here because we shall relate that one.

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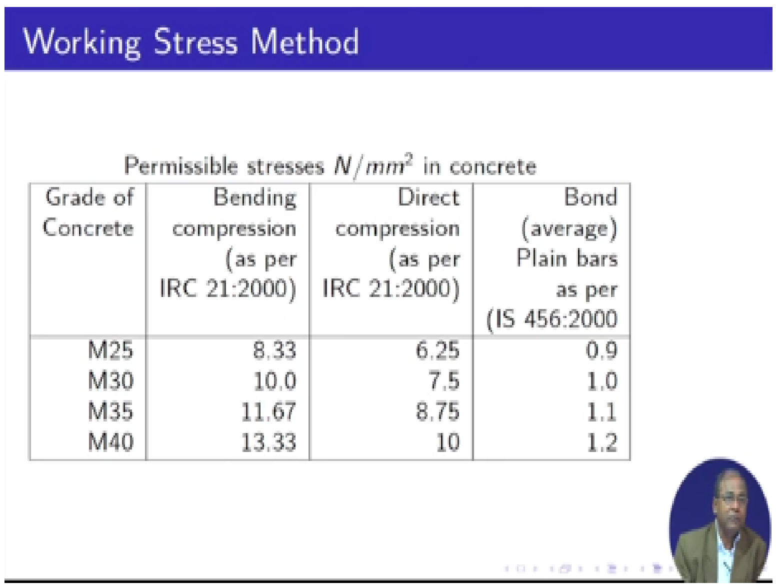

Grade of Concrete	Bending compression (as per IRC 21:2000)	Direct compression (as per IRC 21:2000)	Bond (average) Plain bars as per (IS 456:2000
M25	8.33	6.25	0.9
M30	10.0	7.5	1.0
M35	11.67	8.75	1.1
M40	13.33	10	1.2

The next one we shall get coming to this one here, this one we are taking IRC 21:2000 these values we are taken for direct compression IRC 21:2000 that will taken, so that mean bending follow it is more than the direct one and bond average all that one we have taken from this IS 456 that particular value we have taken here, just to show you this particular were we are taken here just to show you this particular one and this is the bond also equally important and for that we have taken M25 to M40 because for concrete reinforce generally we do not go to M20.

So that is why we generally we go to M35 40 or M30 these are the 3 we go for example whenever we go for residential building we will find out that we always over with the same M20 , M25 or M30 but whenever we go for bridges mainly we go for bridges mainly we go for same M30 M35 M40 if we go for this stress then we shall go for little more M40 M45 like that also we can go, so as I have told you earlier and whenever we are talking a span of bridge we need to say that for that particular bridge particular type of bridge that is also equally important.

So we should we shall see that one that the 10m span that is for the 1 we can say solid slab bridge 20m span that one we can say RCC Tb bridges, so that why we can consider that 31 or we can consider that one say piston stress concrete or 2511 once we can say, so in an 30 that particular one you can say, so these are the things our basic objective is that we should know for a particular span and if you understand that one clearly then if it is I mean into say that if we can design it for 10m span so obviously we can find out little less than 10m see 8m and 9m all little more than 10m say 11m 12m.

So on the business of that we can compared whether the results are coming alright or not, so for bridge engineering one way you can say that we do not have many more of options we can only we can go for few options and if you can solve that one and understand properly what are the reinforcement other things then obviously that next time whenever we do it will be very easy to remember that whether you are in a proper direction or not, that is the one basic idea so now here what I have told you in the last one.

280/3σcbc so M25 M35 M40 this one it means one third, one third of fck, so bending compression in working stress method that will be your one third fck, so this one third so what I mean to say here that 280/3σcbc we see that means I can say 280/fck so I can compare that m value I can write down this one at 280/fck why I am telling that particular on here later on the limit state method you will find out everything we are writing in terms of fck only, so that is why this working stress method whatever formulation we have all those things assuming that these values will be in certain personal safety for safety factor.

Not partial that were shall come later on in the limit state method partial what that is equally important here, so we are considering here safety factor then that one if we consider this one as a 3 then obviously and here we can say 4, so obviously on the basis of that we can correlated with fck only that means we can find out that particular one with the fck only we can consider.

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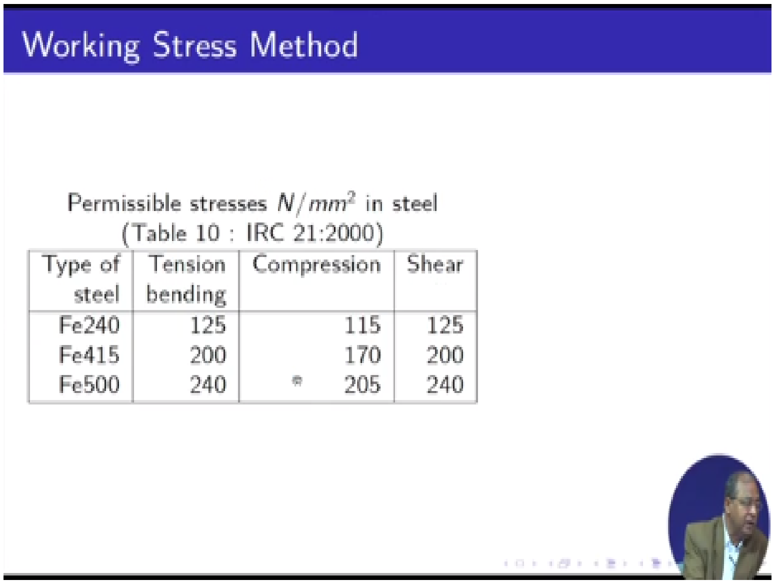

Now next one we are having for steel Fe 240 in IRC 21 Fe 415 Fe 500 and then we are having this values tension bending compression then shear that I have taken from table 10 and just for reference that so I could refer that were code one that code but instead of that I think it is appropriate to information here that values were really stand, so these are the values that means here whenever we are talking this work here Fy and Fck these are the two parameters just to tell you here.

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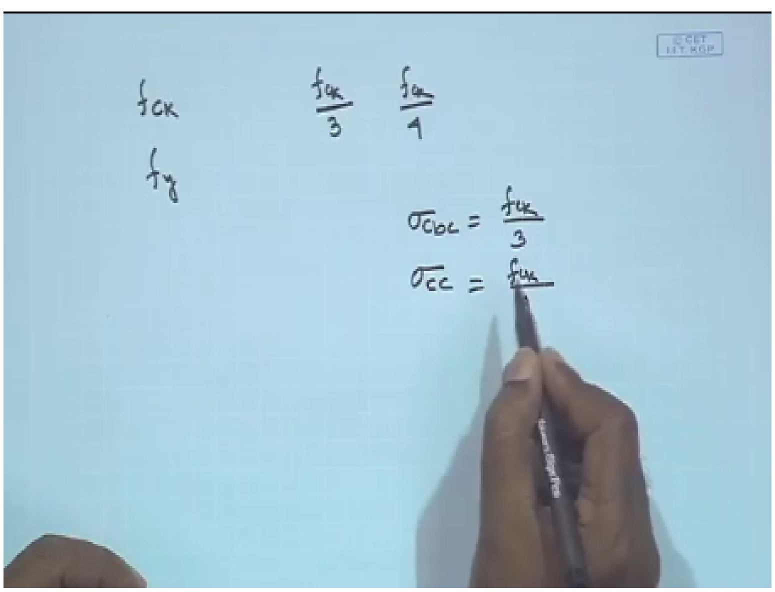

One parameter we are talking see fck another parameter we are talking say fy so with the factor we are getting here something say fck / 3 or fck/ 4 like that, that means this 3 and 4 if I assume that one sequence stand so which is coming from the perusals from then for safety, so I can say I can write down σcbc this one it gives here σcbc so fck/ 3 that stress due to bending under compression in concrete fck = 3 similarly I can write down, σcc which is equal to fck / 4 so this particular one fck/ 4 that we can write it. That means everything in the working stress method also we can write down.

Everything in terms of fck that is the 1 we can find out that one finally at the end of this class we will like to show that particular one would like to converge to a 1 equation where the values may be different but the equation nature of equation is same that is the one our objective to take this particular lecture today in with respect to reinforce concrete.

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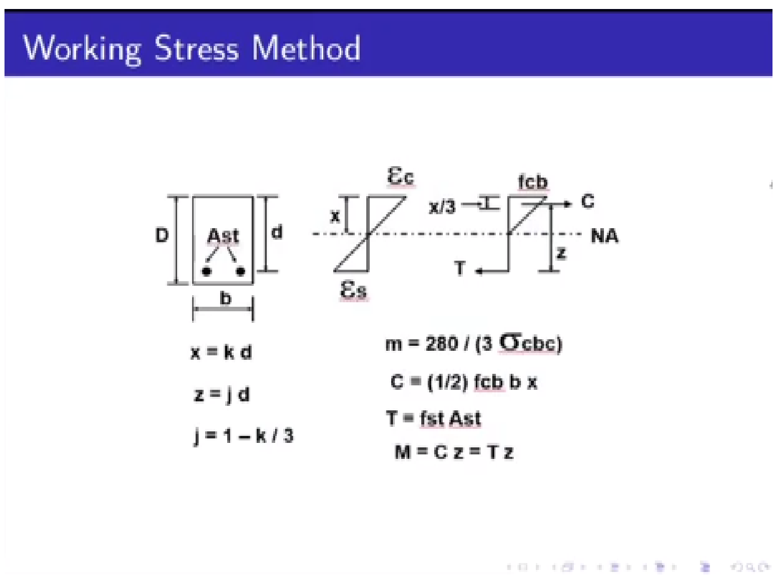

Now maintain here that we can see that most of the cases we go for limit state method of design, but I feel it appropriate to go with the working stress method also because that is very, very important and it will actually easier to understand also before going to the limit state method because whenever we are talking these particular course, so I am assuming that we have already taken that your reinforce concrete design course, but from that particular course to this bridge engineering that is certain kind of changes or say importance will be there.

Certain classification things that we shall take care and because for because of that only we are taking just orientation on reinforce concrete design that we are taking in this particular one, so first one we are taking working stress method and this is the one say your rectangular section that we are having av of steel this is the neutral axis, neutral and then we are having this particular one here that your side stream diagram and this is the fundamental that first assumption that plane sections remain play before and after bending.

This is the one it is not straight line then do not happen, so this is the we are having coming to this one because of that we are having these stress diagram in concrete rectangular one that maximum here and these portion here we are having and as we have assumed that concrete will not taken tension, so because of that these portion that is no tension only then that steel portion while steel is available there only we are having that tension, this is the one we are having I can say like that in that remember that equation.

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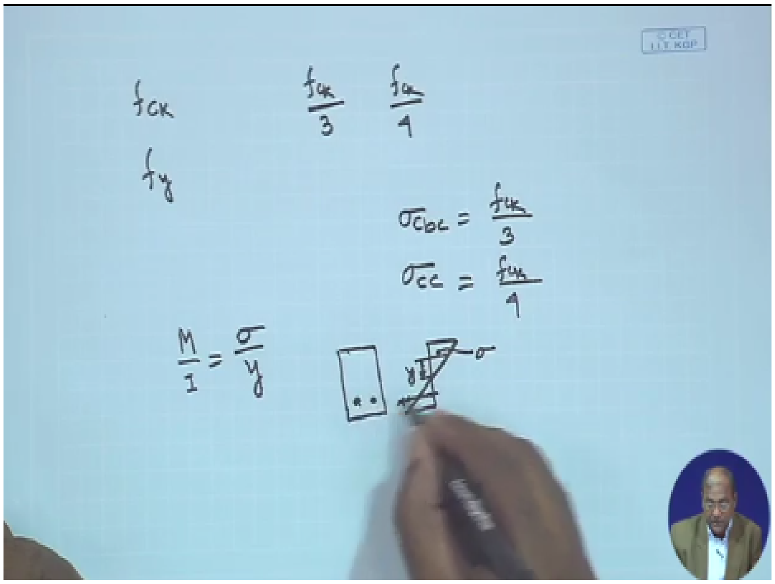

M/ I = σ/ y that means if you take these section, so the stress diagram comes like this, so this is your say y, this y that is here and I second moment is s σ at these particular point σ that we find out, so it for wood for steel we consider the bottom part also, but here we are assuming this portion it will be very less so that is why we are ignoring this portion only at the point where the steel is available that only we taking that means equally we are having that one say your stress strip and you have steel.

So we just simply multiply that, so coming this one here we are having that stress diagram and the ts diagram, and tension in steel and this one at x / 3 these particular one at x / 3 that particular one is and then we are getting that z that is the liberal, so this is the z that is very, very important that z that is your liberal, so we can say we can use a parameter k and see customary to write down the parameter k is here, so x = kd and Z = jd so how this j is related and j = means 1 – k/3 so j = 1 – k because x / 3.

So x / 3 means this were be the value that so j = 1 m = already I have told 280 / σcbc and c will be ½ triangle this tension ½ fcb into x this is fcb and this is x so ½ fcb into x and b which is non that means along the width of the Bheam which is along the width of the Bheam just to give you a idea that one I can say.

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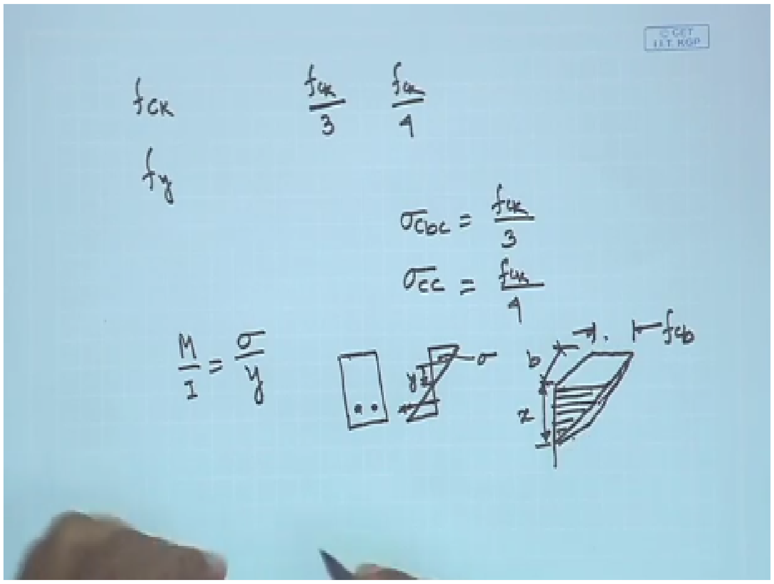

So this is the one we are having b and this is x, and this portion f_{cb} so this why I can say that is this one 1/2 f_{cb} into x into b, so that volume we are getting and that is the one to your compressive force which is acting on concrete, for steel it is very simple t = fst / A into Ast, Ast is the area of steel in tension and fst is the, the stress in steel soT we can find out this one that means this c and T this one should be in equilibrium. This c and T should be in equilibrium and that movement and we call this momentum, momentum resistance that means these momentum resistance will be equal to c times.

Either z or T = z it should be equal because whatever compressive force acting because if the c and T are different then obviously it will not be in static position, it will move, so that is not possible the Bheam whenever width is there a bridge always it is there in the same position, so obviously we cannot say that your c and T will be different at that equilibrium position c and T will be required only thing we can say whether we have got that c and T that how much of it is capacity we have achieved that is very, very important how much capacity we have achieved that will be very important here. So this is the one we get it here this particular one.

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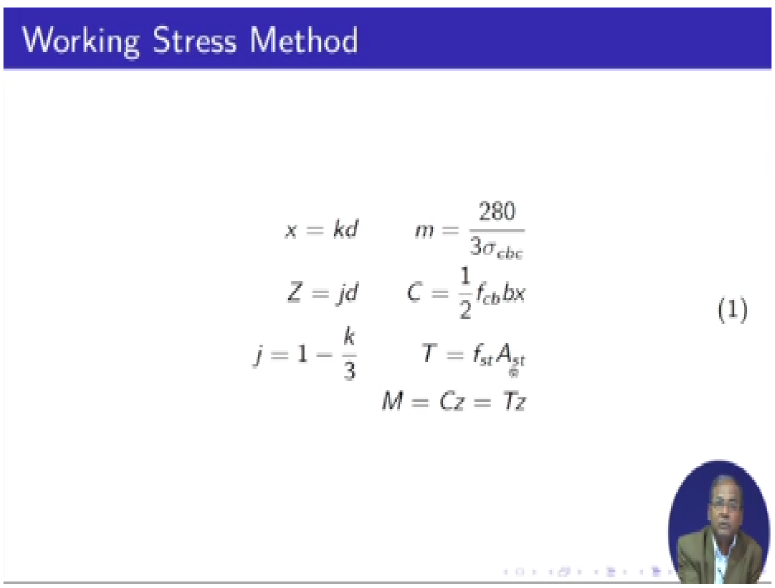

So whatever I have written here just to give you that idea x = kd Z = jd j = 1 – k / 3 like that we can write down this particular equation we can write down.

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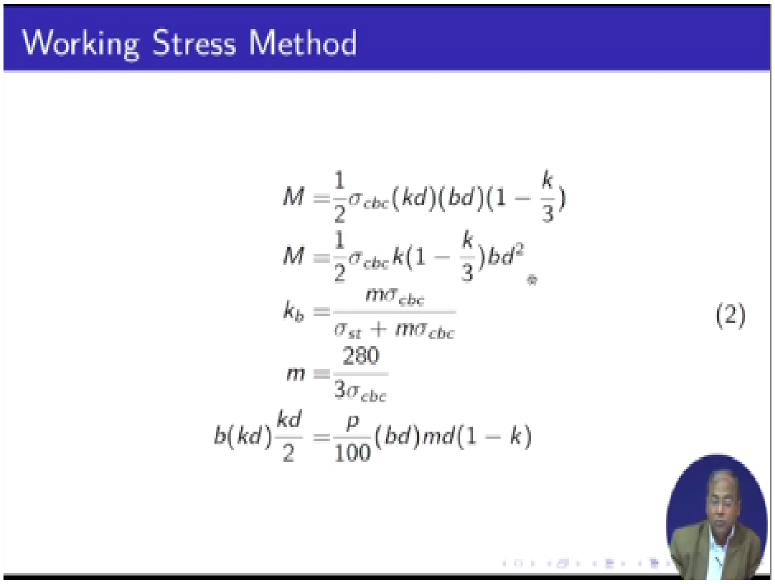

Further we can elaborate this equation here like this M = ½ where from the σcbc is coming σcbc is coming from the permissible stress in bending here this one actually we are talking side bending compression, so we are considering that one say 1/2 σcbc into kd, so please note this one is here and that ½ σcbc kd means x then bd that particular one we are getting 1 – k/3. So if we write down that equation M = 1/2 σcbc k 1 – k / 3 bd^2, so we can find out this particular equation here like this we can find out M = ½ σcbc k 1 – k / 3 bd^2.

So that we can write down so what I can do it here, let us make it this particular equation we shall use it later on so let us just write down that equation here so that I can.

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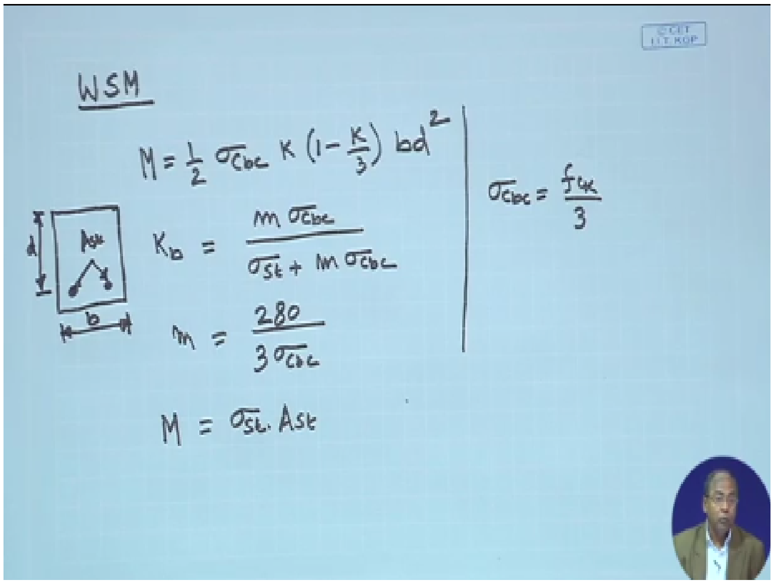

Let tell you so we are talking this one say working stress method whatever we are discussed and M = ½ σcbc k 1 – k/ 3 bd^2 this is the one we can write down further I can write down k_b = m σcbc / σst + m σcbc over m = 280 / 3 σcbc this particular one we can write down here why we shall come back to these particular one page again later on, so here I will like to say σcbc = fck / 3 equal as per that table which is coming one third of that, so these portion let us consider that we are keeping this particular one.

For the time being and then we shall come back to this page we shall come back to page again later on when we shall compare with the limit state method this is very, very important one we can consider here further I can write down that one, let me write down here M = σsc Ast we are writing that one, so let me write down here M = σst Ast and since we are writing down that one so let me write down the draw the cross section of the minimum, so that it will be clear in all respect.

So we can say this is your b and this is d so b and d this one is Ast, so we are getting this factor here let us keep this spectrum here one more equation we have this particular equation we are having here this is very, very important here so let me just clarify this particular equation this is the 1b and this is the 1 xd just give you a idea this particular one here whenever we are talking that particular one here do you like to find out that area, so b into x into x / 2 kd/ 2 this is the 1cg of that compressive force that area p is the percentage of steel of bd into m because we have compare to 1 equivalent area because this one if we concrete, so we have covert that one in the same area.

So m into d1 – k that we can find out here, so that we can find out here so b kd, kd/ 2 P / 100 bd md 1 – k that we can find out that is the one we can consider here that this is the one for the steel and this is for concrete, so this portion from there we can find out many more things we can do it here that means if we know the percentage of steel then from there we can find out the value of k or if we know that k that what is the corresponding value of p that also we can find out that is why this equation also equally important and so let us wrote down this equation here also.

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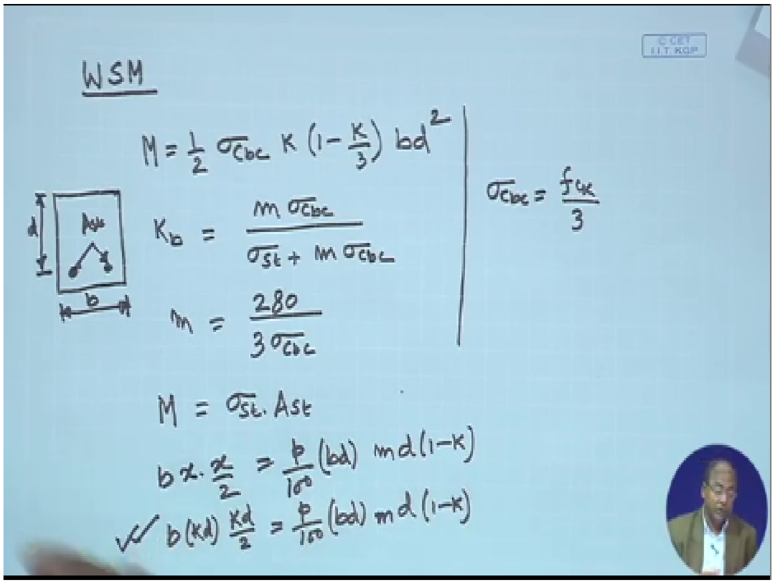

So bx, x / 2 = P / 100 bd percentage of steel md 1 – k or b kd, kd / 2 = 300 bd md 1- k so we are keeping this equation for future essays when we shall consider that in our limit state method.

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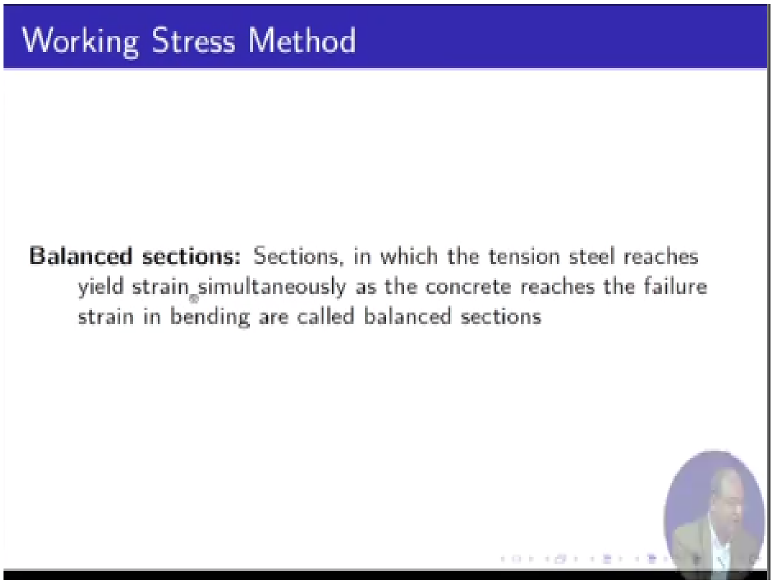

Now coming to this one say balanced sections, just to give you idea when the steel and concrete both reached their capacity then we consider that and obviously it is the most optimum solution, so but which is difficult to get that is called balanced section.

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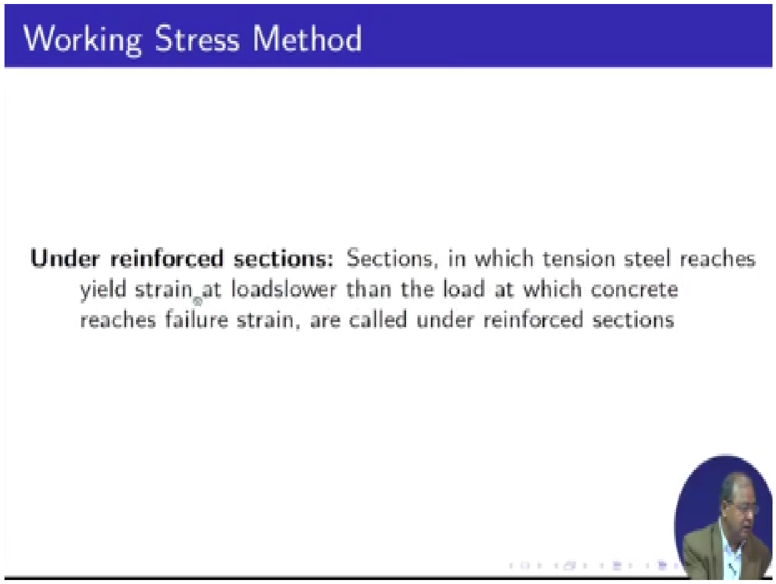

Under reinforced in steel reaches first that is the one called under reinforced and then we are having over reinforced.

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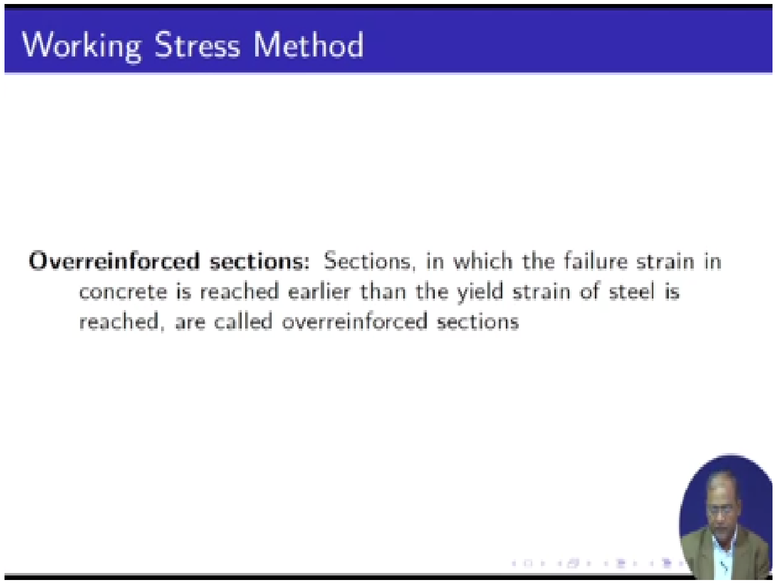

That means when concrete will reach first which is not all desirable because failure in concrete will be abstract sudden but whereas in steel it will give you some time, so that is why it is always better to be make it under reinforced, so that you will get warning we will get warning in your that if there is any problem so that you will get certain warning otherwise we concrete fill first so it will be absorbed it will suddenly we were able to get any warning out if it.

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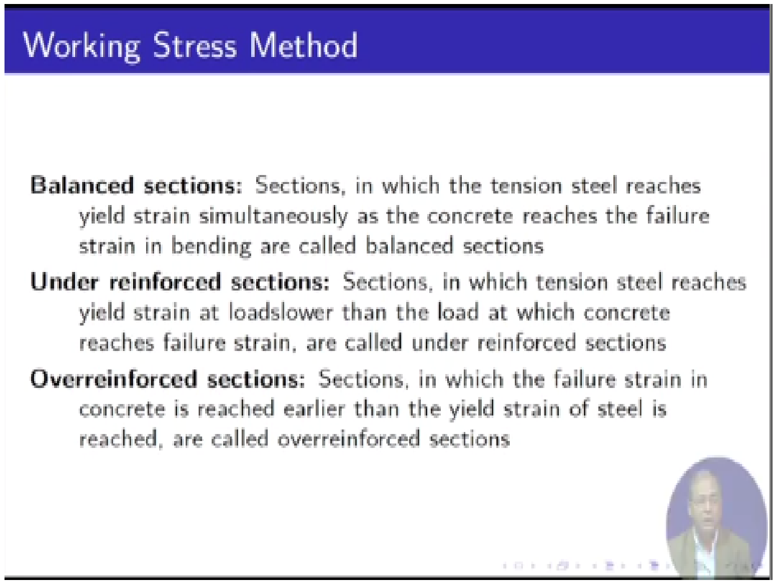

So these are things whatever I have told already while I have already discussed this particular one here.

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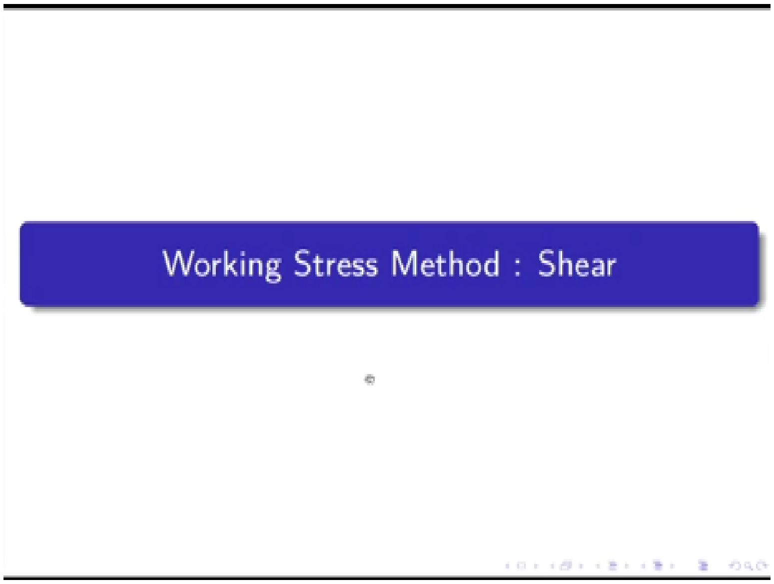

Now coming to the shear we shall come back again just to give you an idea shear.

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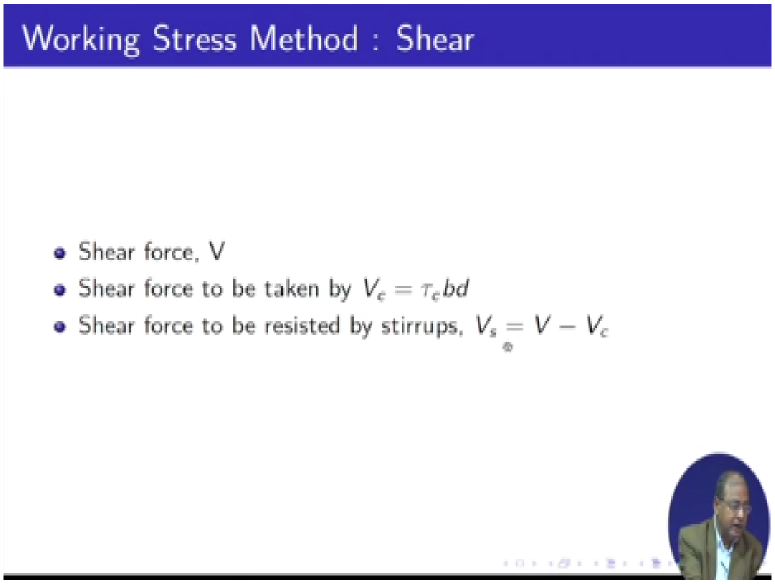

That we are having shear force V then Vc means Tc bd which will be taken by the concreted self and there are aggregate law other things shear force to be resisted by stirrups, so that means remaining 1 Vs which we have to provide by the stirrup.

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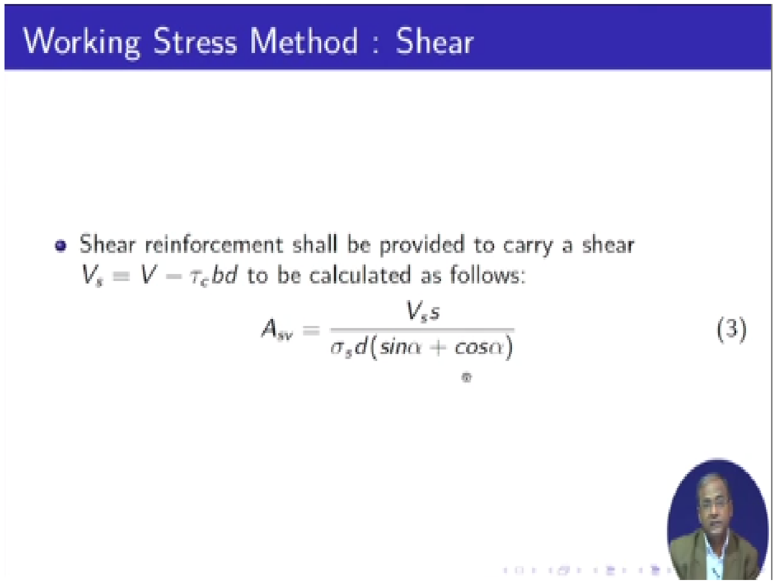

And the formula that occur one for that will be Vs into S bhd sin + Cos α that means if you provide the stirrups in plain manner then you will get this particular equation.

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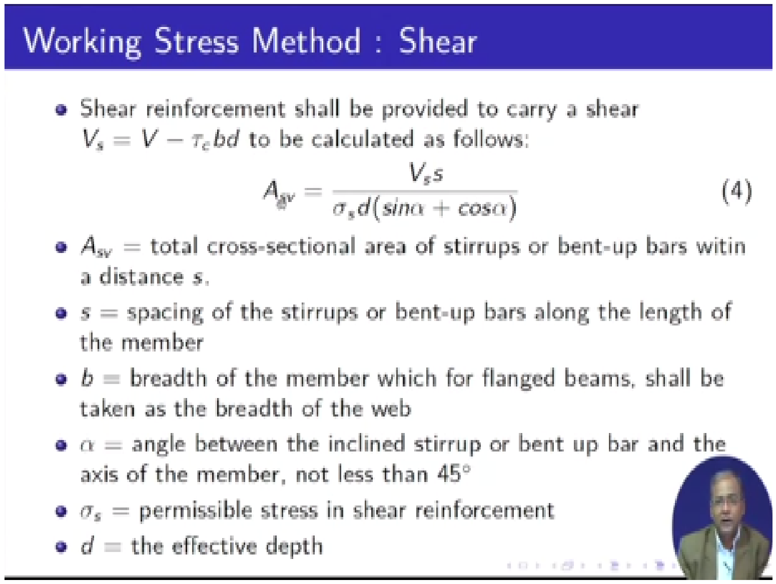

So we can get the thing just to give you idea in one page the same thing whatever we are given Asv = bs into s that one Asv the total Cos if there are two legs two vertical bars, so that means we have to take two ice of that s spacing of the stirrups b breathe of the member α angle between the inclined stirrup not less than 45^0C σS permissible stress in shear reinforcement and d the effective depth, so this is the one from there we can find out how do find out here we can consider α certain value we can consider here.

And then d we will know Bs already we know now the theory that Asv and As generally whatever we do we find out the Asv say 8mm 10mm 12mm dia bar most of the cases we use to legate bar, so 8mm 10mm like that if we use it and on that we see, so that you can find out the Asv because you cannot give any fraction and then you calculate the value of s the spacing of the bar and that then we come to the near it certain regular number, so that I need to say I mean we generate provide something say 100, 125, 150, 200 like that once in the 5mm spacing that we provide.

The value is whatever we get from this computation you should provide less than that, this is the basic idea of that.

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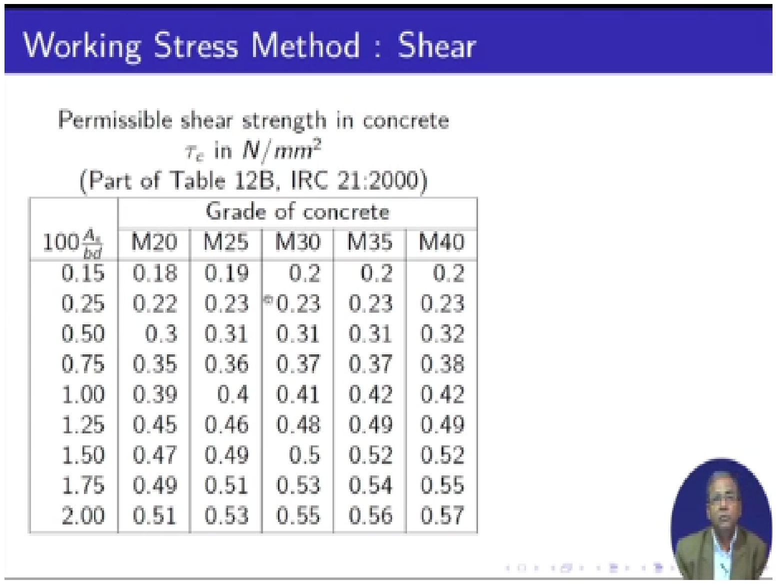

$100\frac{A_s}{bd}$	Grade of concrete				
	M20	M25	M30	M35	M40
0.15	0.18	0.19	0.2	0.2	0.2
0.25	0.22	0.23	0.23	0.23	0.23
0.50	0.3	0.31	0.31	0.31	0.32
0.75	0.35	0.36	0.37	0.37	0.38
1.00	0.39	0.4	0.41	0.42	0.42
1.25	0.45	0.46	0.48	0.49	0.49
1.50	0.47	0.49	0.5	0.52	0.52
1.75	0.49	0.51	0.53	0.54	0.55
2.00	0.51	0.53	0.55	0.56	0.57

And so from the code I have given a part of it part of 12B for complete one through you are have a little more than to, so that occur one if you take it again I have taken M20, 25 30 35 40 so we can get the value of Tc so since we know already we know b and already you know d so you can find out Tc from here that percentage of steel your provided longitude one so Ts so subtract from the actual shear force and provide the reinforcement there, there is certain kind of things are there that minimum reinforcement also we have you have to provide, but even then also in that we shall come later one whenever we shall solve the problem.

So this is the whole idea that we go for it that is for the IRC going to one for working stress method similarly we have IS 456 where we are having that working stress method we having, but these particular one we are our main objectives is that one even if you solve it by working stress method what is the difference that you should know you should know that one not only, only all are limit state method if you check that one how much it comes whenever we are doing working in the working stress method and that also you should know and we should do it.

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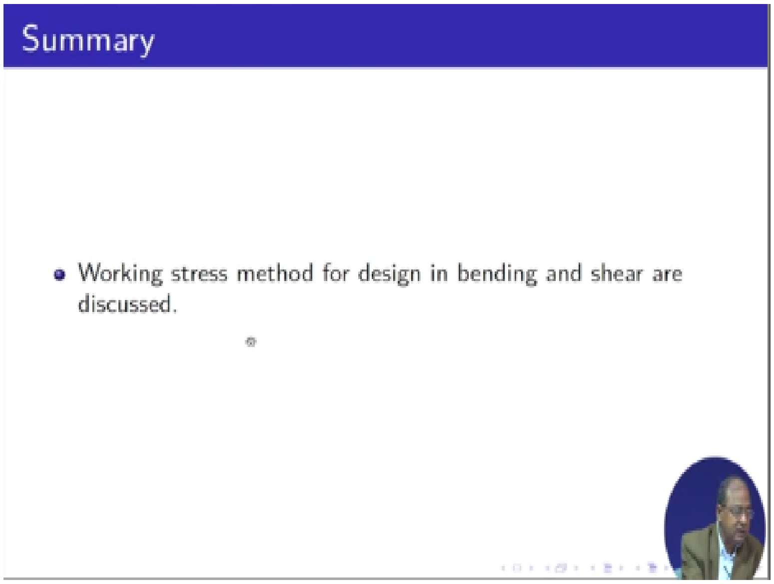

So in summary I will like to say that working stress method for designing bending and shear are discussed here.

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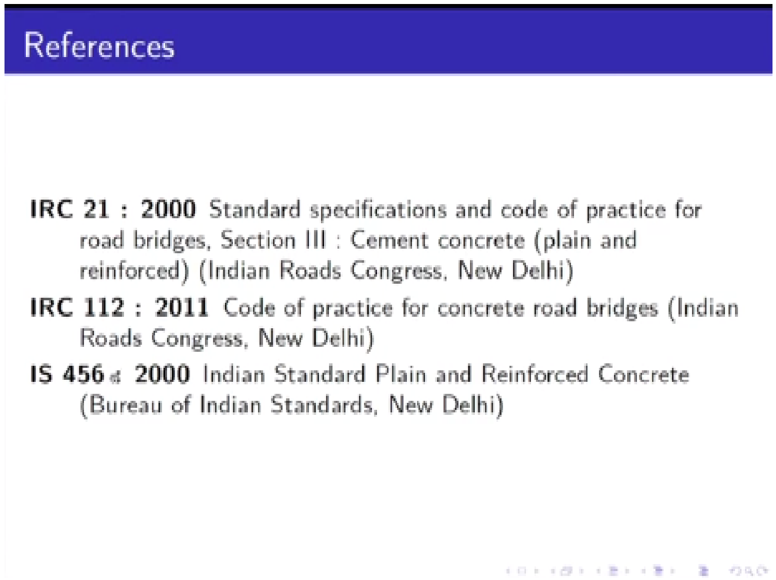

And references means mainly I have told you that element portion from IRC 21 and then we shall find out that next we shall go for IS 456:2000 and then we shall go for shear IRC 112:2011 that we should go, so with this thank you very much.