Advanced Marine Structures
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Lecture - 27
Shear centre – II – Examples

So, we will continue the lectures on advanced marine structures.We will have the lecture 27 on module 1.We have already discussed about the necessity for shear centre, study of shear centre.

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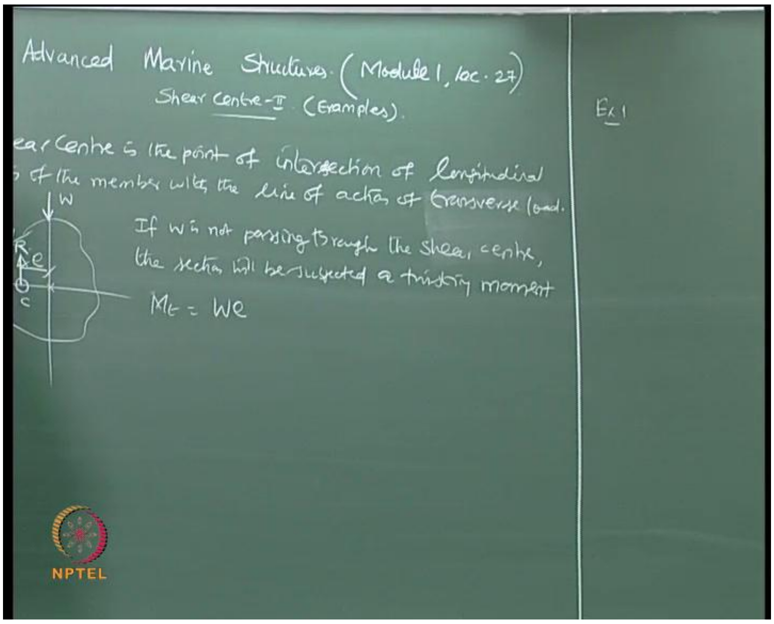

Let us quickly recollect the shear centreis the point of intersection of the longitudinal access of the memberwith the line of action oflateral loads, sorry transverse. So, if you have any cross section;this becomes a centroid of a cross section; this becomes my force acting;whereas this becomes the point of Cwhich you called as shear centre and this is the point where W is actingI can say this as VR resultant shear force and this is W, and the distance between these two is what we call ase.So,it is understoodthat ifW is not passing throughthe shear centrethe section will be subjected toa twisting moment whichI call as M tit is given by Win to e. Generally thin cylindrical sectionswhere we are talking about asymmetric sectioncommonly used in the marine structures.We know that they are very good in bending, but they are very poorly performing in torsion so this becomes the problem that when the structure is subjected to twisting moment, one must examine this for the load satisfactory transfer in case of shear.

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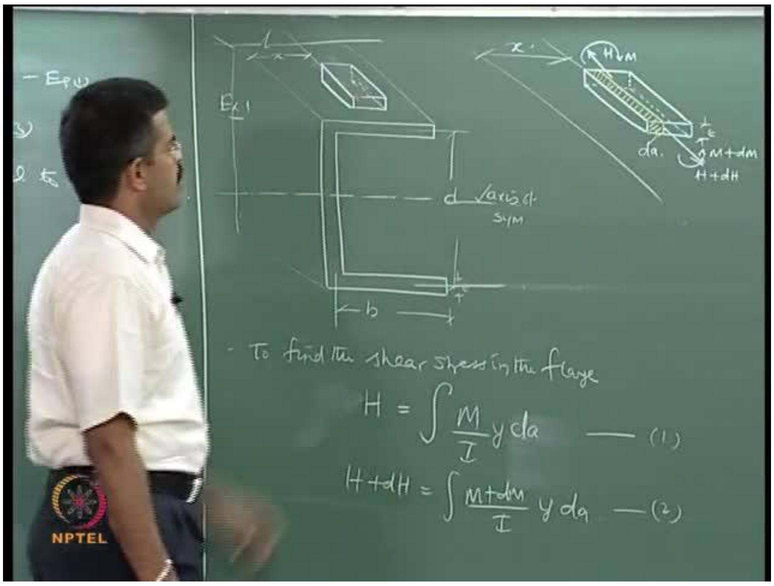

So, we will take up another example today.We did one example of a channel section yesterday.We will take up another exampleof a channel section now and see howI can compute the shear centre, this is my channel section.Let us say the section has the breadth band thicknesst and the depththis d of cross section as one axis of symmetrywhich is called as axis of symmetry.Now, consider an element here.This element is measured at a distancex 1 here and ifI drawelement separately.

Now, understandthis distance what we sayas x,the element has a thickness t and the element hasthe forces acting like this.Let us say this is Hand this is H plus d Hand if this is M and this is Mplus d M and of courseI also consider an elemental area, this is d aand so on.Now, let us sayI want to find the horizontalto findtheshear space in the flange.We all know this the flange and this is the wave.So, tauthe shear space in the flange to start with let us say let us compute the horizontal force H here,His M byI y d m,d athus, this acting on an elemental area d a sorryd a,whereas H plus d His M plus d MbyI.

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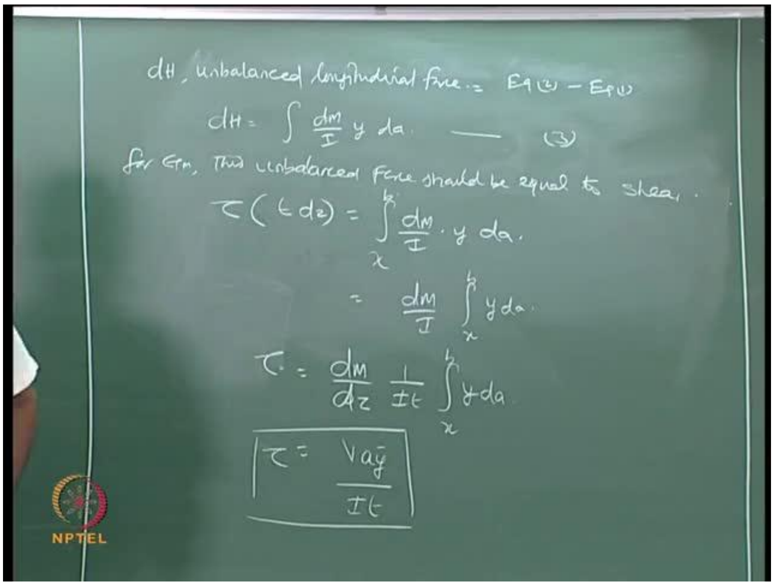

So, d Hwhich is the unbalancedlongitudinal forceis given by let us sayI call this equation number 1,equation number 2.I can say equation 2minus equation 1.So, d His simply integral ofd M byI into y of d a.Now, for equilibriumthis unbalancedforceshould beequal toshear therefore, tau intothe shear area which we can say in this case t d zbecauseI am measuring the thickness andI want the elemental strip should be considered in this section,let sayd a t d zshould be equal to let say integral d M byIinto y d a.Now, the limit what we have for this piece is varying from let us say x to b that is all it is.

Okay, varies from x to bI am working about thisso it varies from x to b.It starts from x and goes till b that is what therange of the pieces.So, this can now give metau asI can rewrite this asd M byIb y d a.Therefore, tau can be we can sayd M by d z 1 byI tintegral x to b y d a.We all know that d M by d z will be V, integral d a will be ay bar that isthe first moment divided byI t,that (( )) the equationwhich we used in the last section to compute the shear stress.So, in this caseIis a moment of inertia of the whole section.Now, let us try to apply this principle back again from this problem and see how we can compute the shear centre.I will rub this, so this equation if you remember you haveused,it is a general expression which we have used in the last lecturealso.

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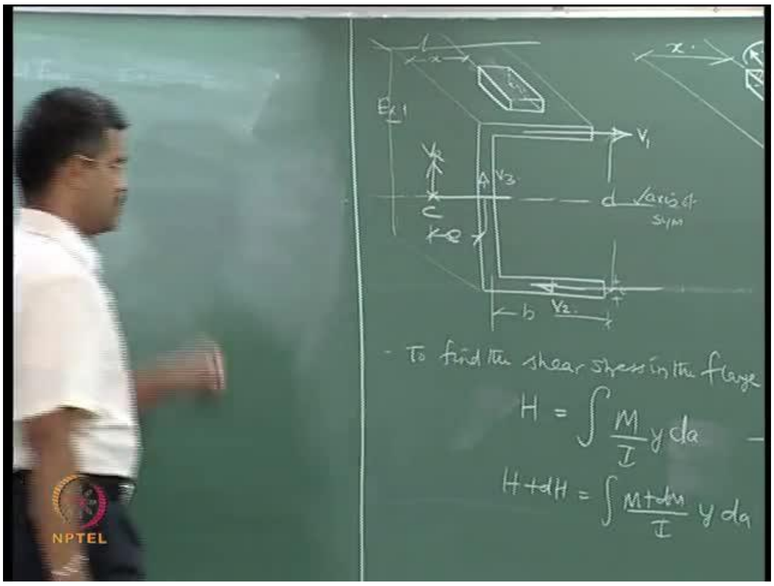

Let us say, in this problem I havethe r is acting somewhere hereand this is my shear centreC, this is V rthat is resultantand this measure from the pace of the channel ase.And let us say this is my shearthe upper one,this my shear draw here one and of course the shear here whichyou call as V3.

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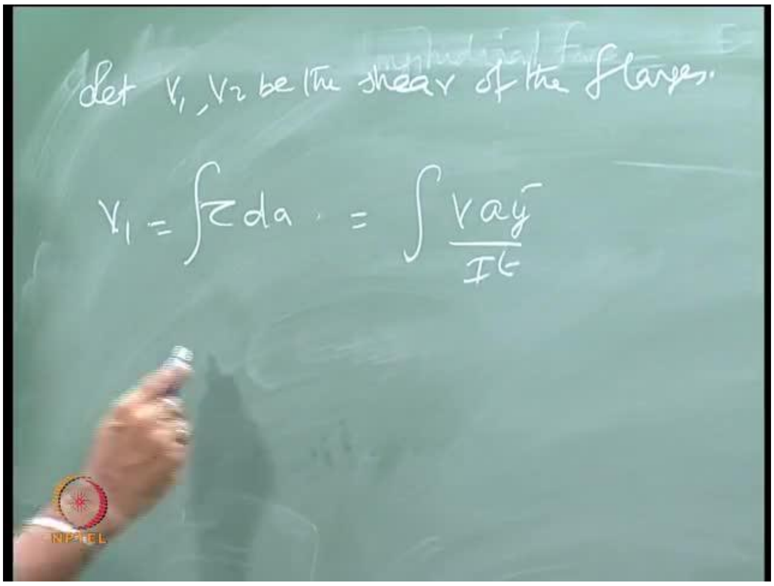

So, letV1,V2 be the shearof the flanges.LetV1 now will be equal tosimply tau d aso which is Va y barI t.So,of course t is a thickness,we have written it heret is a thicknessand the section is available already.

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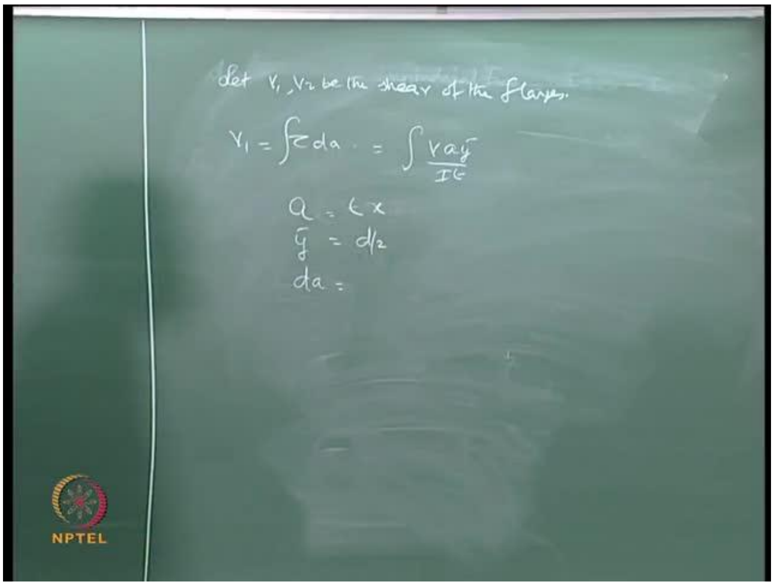

Let us see ain my case is going to be t into x because I am considering a section which is x distance from here.So, t into xy bar is going to be distance of that from the centre,which will be d by 2and d a.

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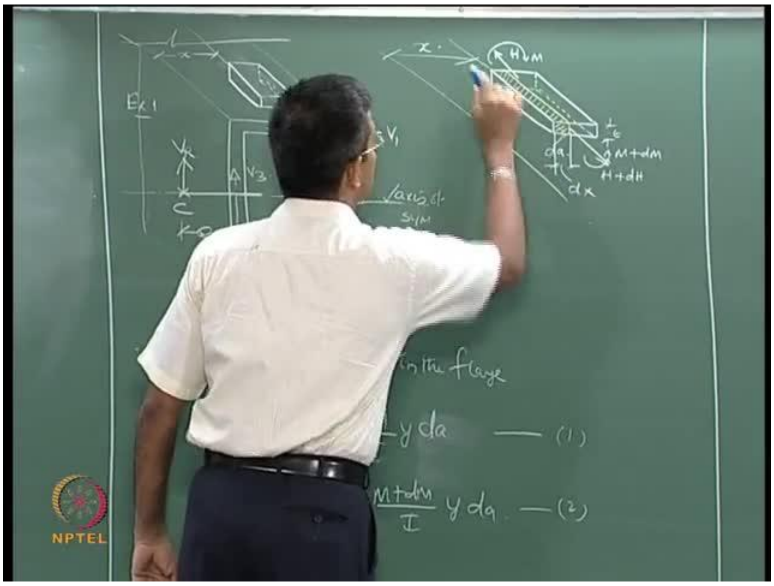

So, the width of the strip say d x x and d x.

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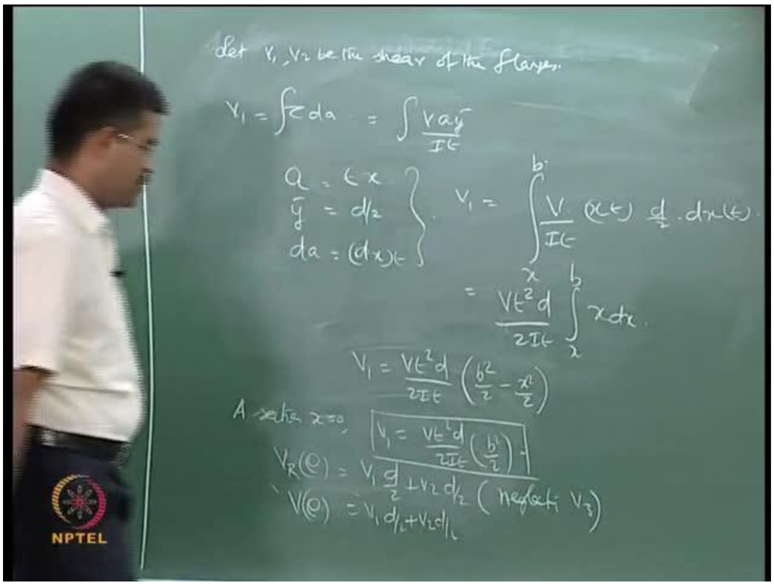

So, d a is obviously d x into t substituting back V1will be let us say Vx td by 2d xby I t.And this variation is going to be fromlimits of x to b.So, integrate and tell me whatthe value of V 1 is?So, it is going to be V t square dby 2I t of integral x to b, let us sayx d x.So,I can simply say V1 is going to beV t square d by 2I t ofb square by 2 minus x square. I want to consider the section where x is 0 here.So, section whereV1 will beV t square d by 2I tb square by 2.

Now, we all know that V r is the resultant force which is going to be equal to the sum of V1 plus V2.So, let us take the moment about this.So,I should say that VR into ethat is taking moment about this pointwill be equal toV1 into d by 2plus V2 into d by2 neglecting V3and we all know V r is actually equal to the total shear in the cross section which is going to be V1 d by 2 plus V2 d by 2.

So, in this expression you know V,you know V1, because V1 is given expression here because in V1 we already know t d all are geometric dimensions we already know them,I is the moment of inertia the whole section, d is again a geometric parameter which is known from here, the only unknown in equation could be e that would locate the shear centre from the pace of the section.So, this will give you the shear centre equation for easily for the channel section.Let us do one more examplethese are common sections which are used for members of marine structures.So, we must know how to compute theshear centers of these.

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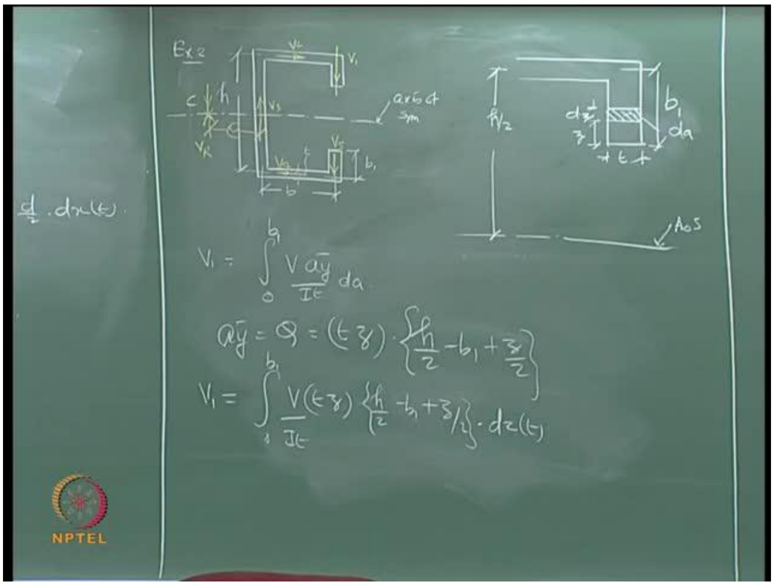

Let us take of another example where the slightdeviation in the geometrywith a box section.This is my sectionthishas anaxis of symmetrywhich marked here,an axis of symmetry,the dimensions are available.Let us say this is band this is b 1and of coursethe total thickness for the section is t and this dimensionh. So,I have the shear values,I call this shear as V1,V2,V3,V4and V5and this is my resultant here;this my shear centre.The total shear forces acting hereand this going to be VR andI measuring e from the centre.That is my e.Let us take a specific case of this and try to work out V1.

So, this is my piece,this is my axis of symmetry,I consider the piece on a specific thicknessand we all know that this is going to beh by 2and of course, this valueis b 1, this valueis t and this thickness is zand this thickness is d z.So, ifyou want to work out V1V a y bar byI t integral,V a y bar byI td a which varies from 0 to b 1,t in this case is the thickness of the section considered, this my thickness remainsand I is moment of inertia whole section and let us work out what is this a y barwhich is otherwise called as capital Q in the literature.

Can you give me what is a y bar?Area a is an area above the section under consideration, y bar is the c g of that distance from the section.So, a y bar what is going to be a y bar?t z yes, t and zandI want y bar, what will be the y bar value?Think aboutit and then tell me.Yes, I want actually this distance is it not?This will be h by 2 h by 2 minus b 1.Let us say,yes h by 2minus b 1, good.So, we are here plus z by 2 is it not.This is, integrate this,yes, everything hereso v 1 is going to be simply substitute these values andintegrate them.

So, integration limits 0 to b 1Vt z h by 2 minus V1 plus z by 2.Yes d z z is d zt d z that is d a,that is d a of course, byI t.d a is t d z is it not?Thisarea, hatched area, this is what we call asd a.Now, you have all the variables and you know the limits and you know the variables and integrate it, give me the value of V1.So, let me check this V byIt t z which by2 minus V1plus z by 2 t d z.Yes,what would be the value of V1?

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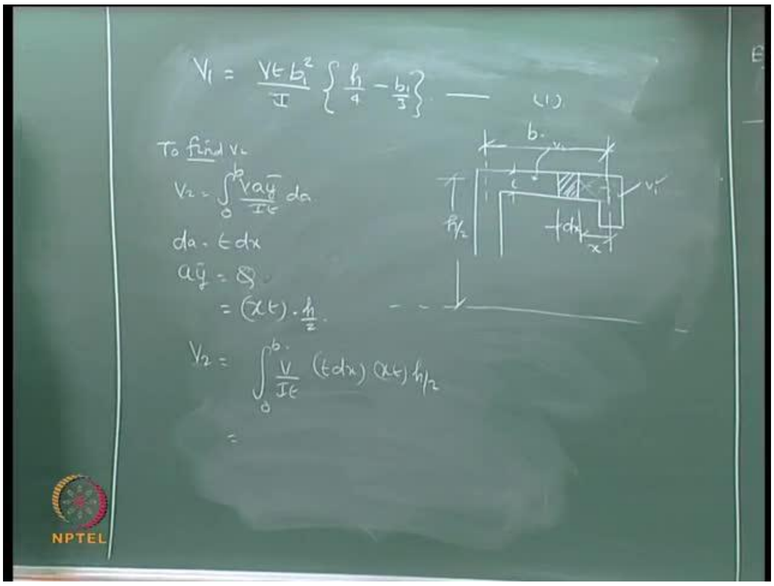

So,V1 is given byhave to substituting the limits for the equation it becomes V tb 1 square byI sorry byIh by 4minus b 1 by 3,call this equation number 1.Are you getting this?Let us do for the second piece which is V2.I will draw the figure again here to find V2.So, the figure is here,till the centre we already considered, this is V1I am looking from this centre till this centre for this piece that isV2.

Okay, so let me consider a sectionwhich is at a distance x from hereand distance or thickness d x and of course, this thickness we knowits t and this may acts of symmetry and we know this distanceis h by 2 and we already know from the figure this valueis b.V t b 1 square by I as b 4 minus b 1 by 3.So, what would be the d a for this?V2 is going to be integral of V a y barI bI t d a let us say what is going to be d a for this case,the elemental area?Is going to bet into d x is it not?This d x is t and what is a or what is a y bar?That is nothing but Q,what is this value for this problem? I am looking for the strip here, this portion.So, x into t,is it not?And what is the y bar of that strip from the sub symmetry sorryh by 2.

Why?This is already considered know, h by 2till the centre is no minus 3 by 2 here till the centre, h by 2.This portion is already considered, this is alreadydone in V1 is it not?So,we are only talking about V2.So, substitute back and what will be the limits for this?x is varying from,varying from 0 to b.Good, so substitute this and get me V2.So,V2 is going to be integration ofV byI t, t d x,x t h by 2.Yes,0 to b.So, this confirms to V t byI.

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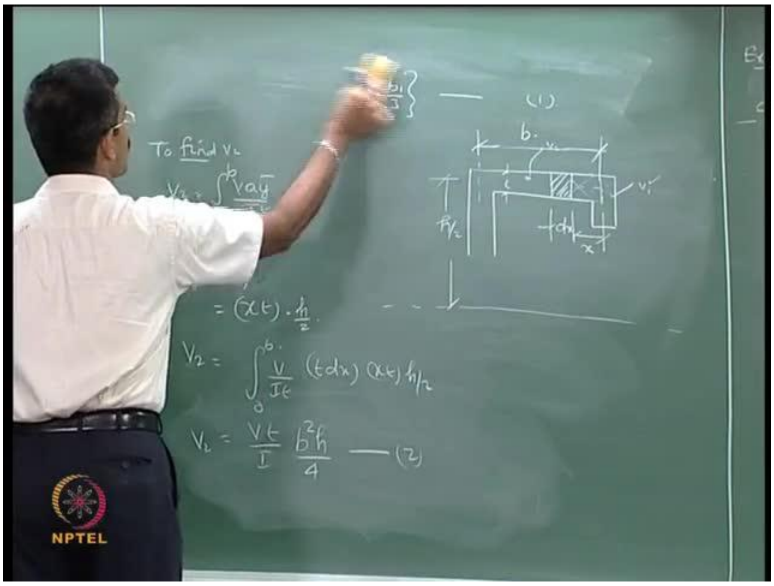

b square h by 4, that ismy V2,equation number2.I thinkI will remove this; we will retain V1 there so it is easy for us to write the expression.

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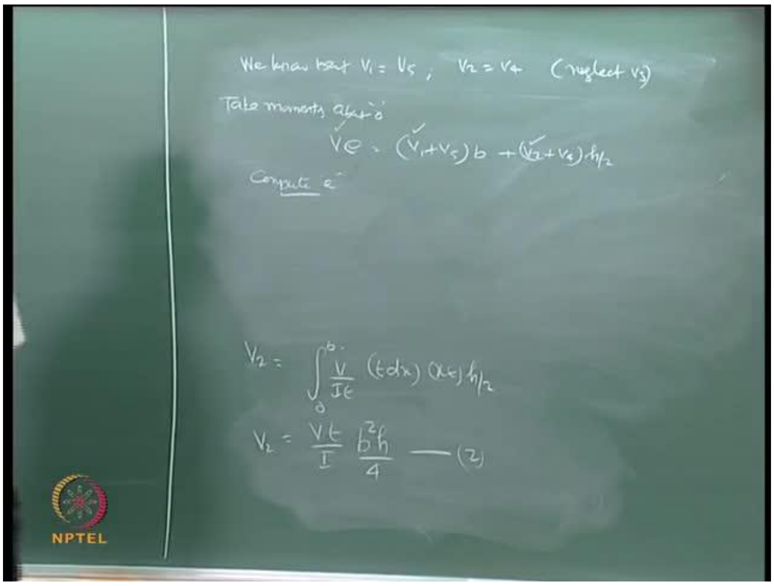

We already know that,we knowthat V1 will be equal to V5andV2 will be equal toV4.We will neglectweb by themean shear by the web.Let us take moment about this point.So, we into etaking moments about this point,you can say V into e is V1plus V5of b, is it not? Plus V2 plus V4 ofh by 2.So, in this case the total shear force resultant shear we know in this sectionV1 and V2, we already have the expressions 1 and 2.V4 and V5 are same as them respectively,V and h are geometric dimension known to me,V e can be computeda compute,is it not?Which is a shear centrefrom the centre to the point Cis what it is. Wewill quickly do one design problem and try to understand this,any doubt here?

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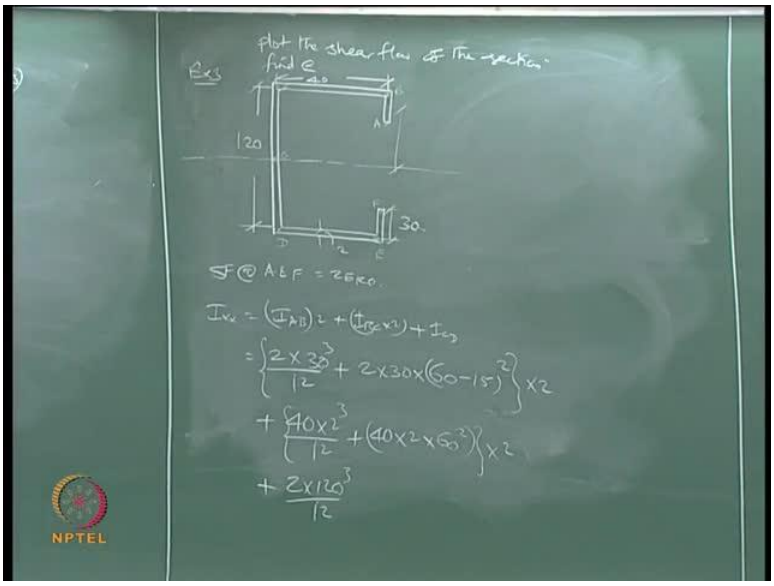

Let us say example 3giving a problemI want you to do this quickly.My axis of symmetrywhatI want to plot isplot the shear flow of the section, that is one part and also finde, that is the distance of the shear centre for the given section.The section has dimensions like this;This is 40, all the dimensions and its centre,this is 40,this is 120all the dimensions center tocenter is 120 and of course, this is 30and the thickness is 2through and through the constants.Let us designate these points,let us say this is my point A, point B,C,I call this as O,D,E and Fwe already know shear force flow at A and F are 0,why?Because a y bar will be 0 in this case, is it not?

There is no a y bar here therefore it is 0.QQ value will be 0.So,I want to compute the shear force at b or the shear flow at b, but before thatI want to do the moment of inertia of the entire section, is it not?So, let us try to find out moment of inertia of the entire section is let us sayI a binto 2,is it not?I a b into 2, becauseI a b and EF are same plusIBCinto 2plusIC D,let us quickly find out this very simple,let us find out this.Yes,I a b, quick.

Okay2 into30cube by 12plus a k square that is 2 into 30 into now 30 is to the centre.Yes, in the original derivation b1 is to the centre.I want the distance of this from here sowhat would be this?That is whatI am interested in here k square, what would be that?60minus 15, is it notwhole square.This is for ABof course, into 2.IBC40 into 2cube by 12plus40into 2 in the c g of this from here which is simply60 square,is it right?Into 2 plus 2 into 120cube by 12,this will give me I x axis,what is this value quick?Quick,quick.!

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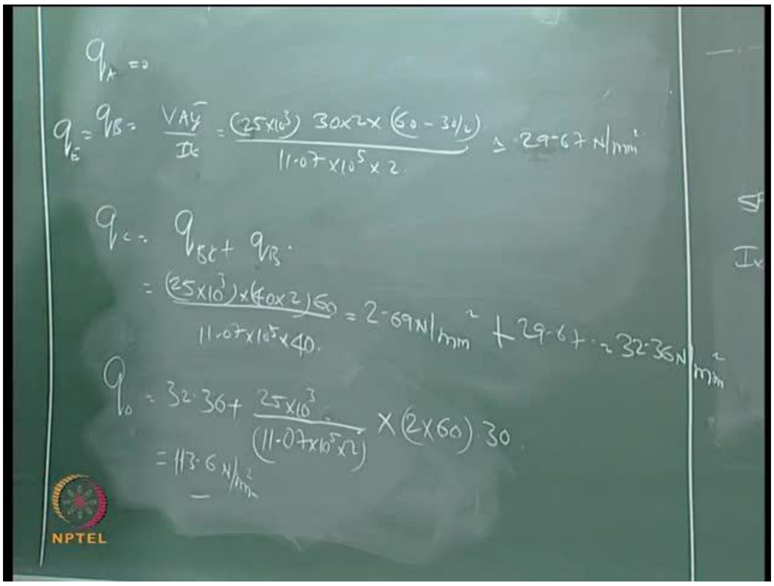

It is 2.4310 power 55.7610 power 5is it 11.07 power 4, is it?Let us try to find a shear flow atpoint Bq B at q A it is 0.So, let us find at q Bshear towards B it will beVA y bar byI t.

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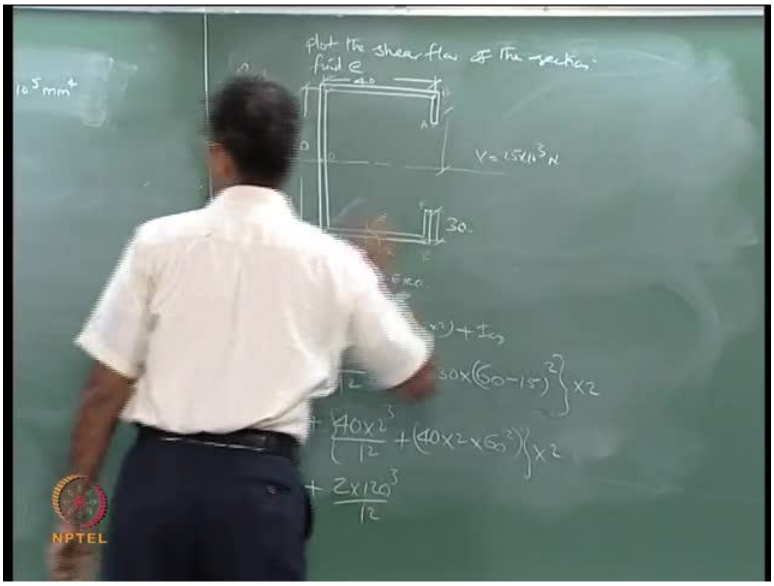

Okay, V in this problemis 25 kilo Newtons,is what?25 into 10 power 3a y bar of this which is 30into 2 into 60minus 30 by 2,that is may be a y bar,I is 11.07 into 10 power 5 thickness is 2.So, this value comes to30 approximatelythe value is 29.67 Newton per m m square whichis as same as q E.You want to find at q CwhichI should sayq of BCplus q B,q at B.So, this piece plus shear at Bthat is what it is.So, which will be2510 power 3 that is Va y bar that is 40 into 2that is a, and y bar is anyway going to be 60 divided by 11.07 into 10 power 5 into B2.How much is this?This is not 2, the width of thesection is 40is 40.B here,the t here is the width at the section considered.

So, this value comes to 2.69you can check that.So, this plus whateverI have that is 29.67 that is my q C.Let ustalk about q o.Let usset this point here q owhatever value have here 29.67 plus 2.69 how much is this?This is 32.36.So,I should say32.36 plus V a y bar becauseof the section which is going to be2510 power 3byI is 11.0710 power 5into 2 that isI ta y bar which will be2 into 60 into 30.So, this comes to113.6 Newton per mm square.

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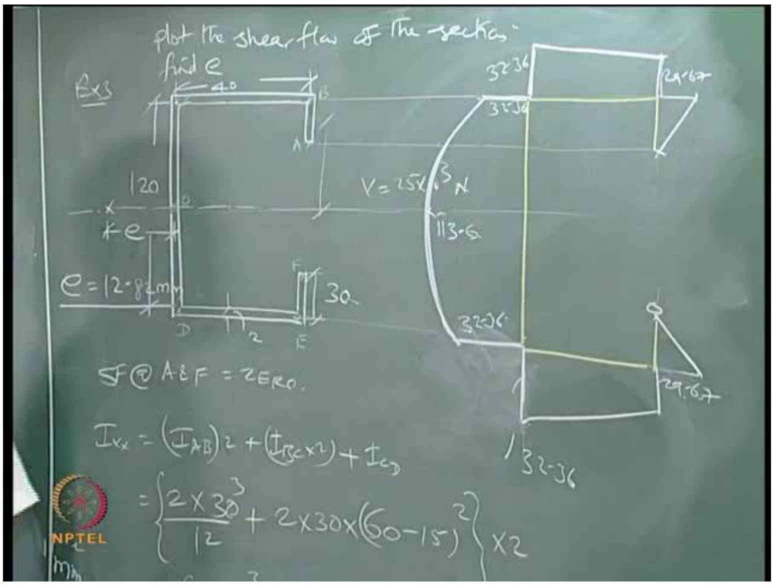

So, if I try to plot this.So, this point it is 0and this point it is 29.67 and 29.67 then 32. Something,so, this is 32.36,this is 29.67,thensimilarly, here this point it is 0, 29.67,29.67 and 32, variation at the centre is 113from various.This is 113.6this is32.36and 32.36.Say, this is my section whichI am marking in yellow color. So, obviously this value becomes29.67, this is 0,29.67 and this value becomes 32.36.Of course, this is not correct.This value should be 32.36 and centrethis value is 113.6.So, the variation is shown of the shear flow is shown like this.

Now,so we have completed discussions on shear centre.The next lecture we will talk about the combination of load effects and plastic effectson sections, plastic capacity of sections and then the collision loads and impact loads and marine structures.

Thank you.