Ocean Structures and Materials

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Module - 2
Lecture - 8
Design adequacy - Example II

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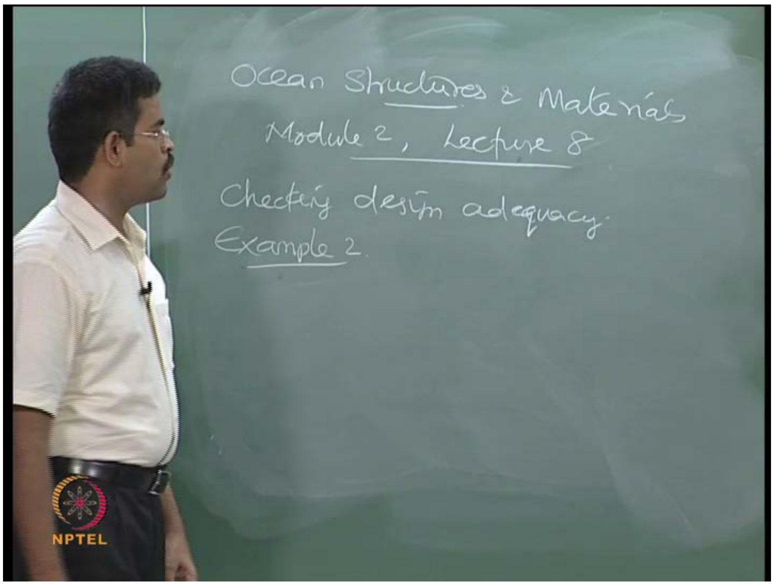

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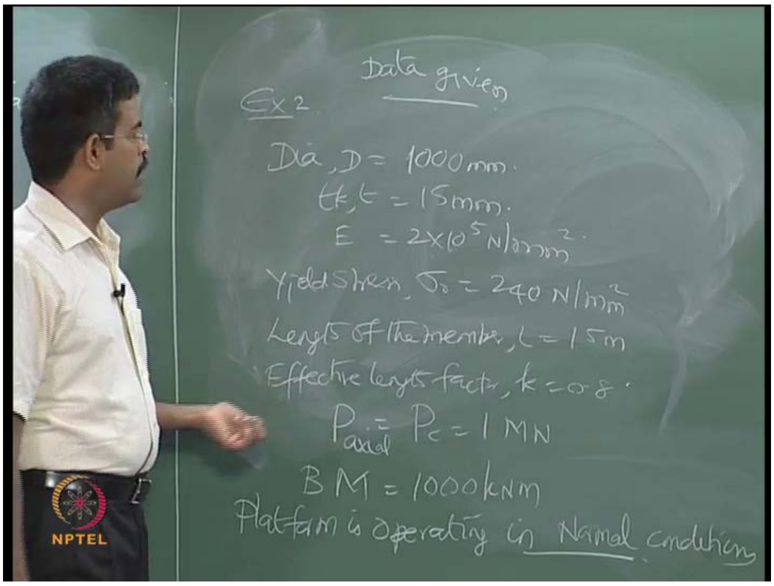

Of the given members using international codes, in the last lecture, we saw an example problem, the member subjected to axial compressive force; we examined the adequacy to design by using equations given in ABS-2008. In this lecture, we will take up another example 2, where I will show you how design adequacy can be check for a given member by the data as given in the blackboard here. The diameter the member is 1000 millimeters, thickness is 15 millimeter, Young's modulus the material is given, yield stress value is given, length of the member and effective length factors are given and axial force applied on the member is 1 mega-Newton, whereas the member is also subjected to bending movement of 1000 kilo-Newton meter.

Now, there is a combined action of axial force in bending and platform is under normal operating conditions. Let us see how I will examine the adequacy of this member using international codal provision given in the course.

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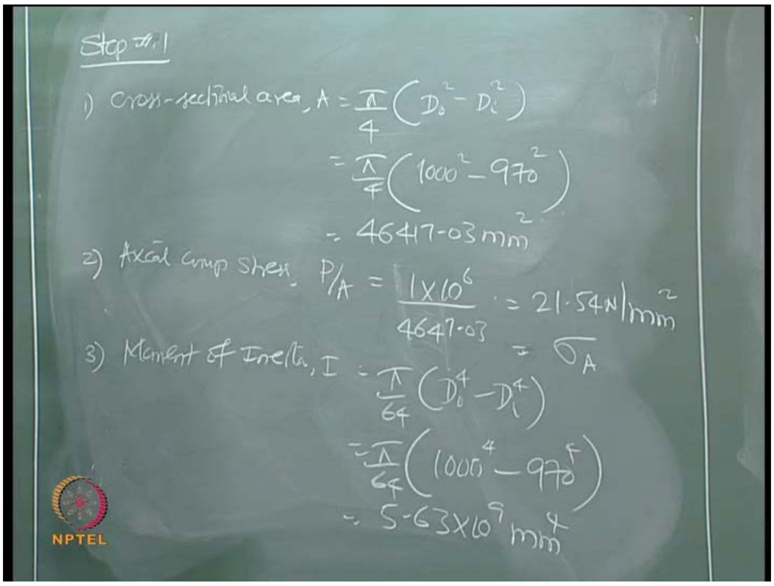

So, let us as usual start with step number 1. Let us see the cross sectional area. So, the thickness is 15 millimeter, let us see compute axial compressive stress, which is P by A, which I call as sigma. Next, compute the moment of inertia, mm to the power 4.

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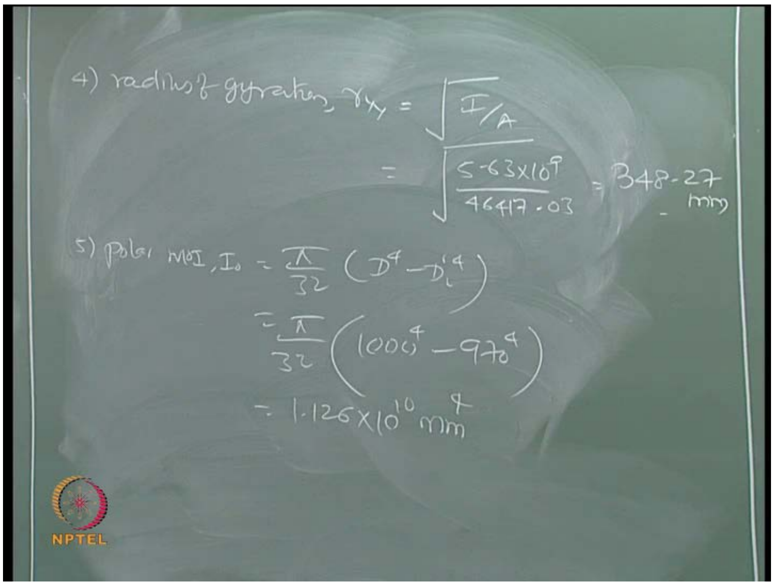

Let us work out the radius of variation. Now, I work about the minimum axis, but being a circular member, above xx and yy will be same, which is nothing but root of I by A, which works out to be 348.27 millimeters. Let us work out the polar moment of inertia, I naught, which is…

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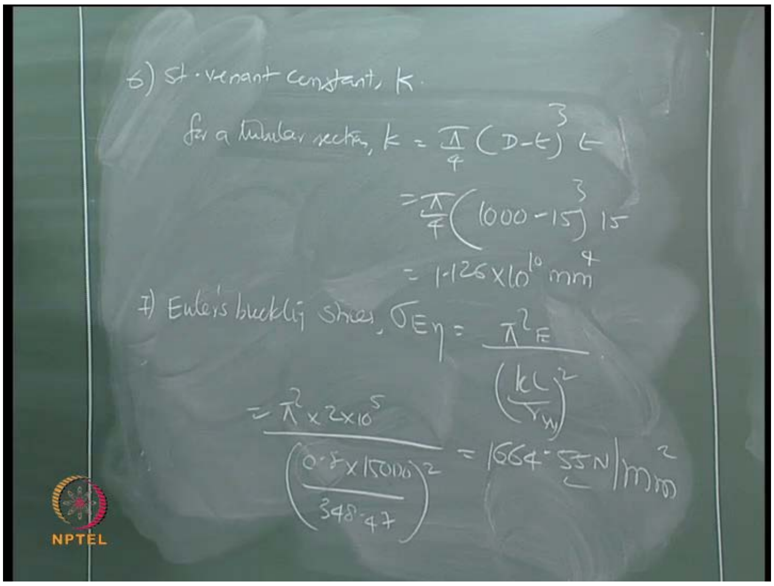

Saint Venant’s constant, capital K…

So, for a tubular section K is given by…

Euler's buckling stress sigma E eta…

So, 0.8 is the factor of effective length. Length is, overall length is 15 meters, so pi square E by k l by r yy square. So, I get this value as 164.55 Newton per mm square.

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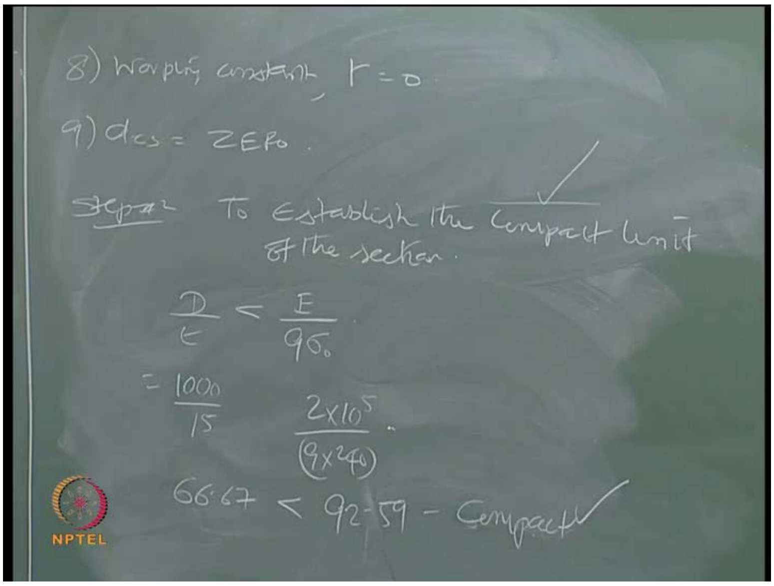

Warping constant is 0 because a section is symmetric and circular and d CS, that is, distance between centroid and (( )) centroid is again 0 for the section being symmetric and circular. So, in step number 1, we compute all the basic parameters and derive certain equations and formulas depending upon the values and substitute them. We get the basic values that they generally require for the design check.

Let us do step number 2. Now, to establish the compact limit of the section, I want to check whether the section is compact or not. Ladies and gentleman, you will agree now, that if I establish the section is compact, and then I can always say the buckling failure will not prelude the actual compressive acting on the member. So, I have to establish whether the given section remains compact for my dimensions. So, D by t, if it is less then E by 9 sigma naught, then I can say, section is remaining compact. In my case, it is 1000 by 15 and the value is 2 10 power 5 by 9 of 240. So, this is 66.67 and this is 92.59 is less, section is compact here. Also, this is a major check. Whenever you get a non-compact section, it is advisable to convert the given section to compact section, either by decreasing the diameter or by increasing the thickness because having compact sections in the design is always advantageous.

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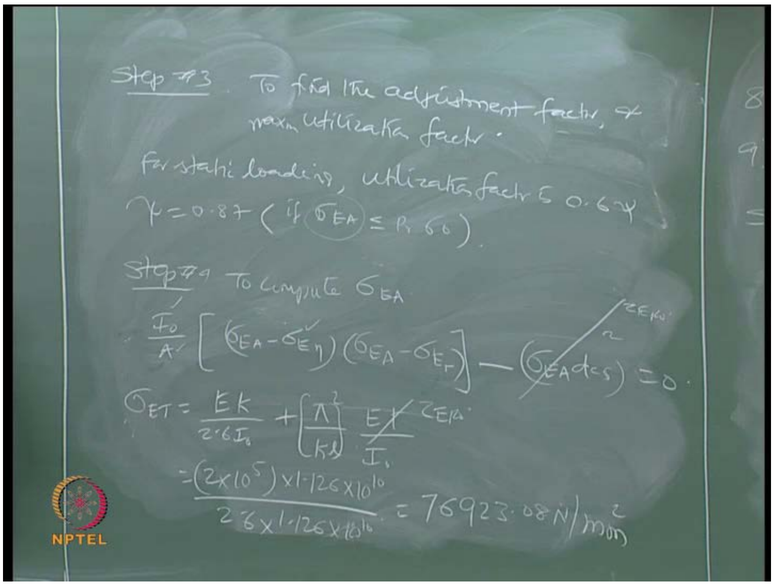

So, step number 3, to find the adjustment factor and maximum utilization factor. For static loading, the utilization factor is 0.6 of psi and psi is 0.87. If sigma EA is less than or equal to P r sigma naught, sigma EA we have to compute. So, let us compute the elastic buckling stress sigma E A. from the quadratic equation…

So, in my case since d CS is 0, this term goes away, I know I naught, and I know A from the first step, I know sigma E eta, just now we computed, I have to compute the sigma E t, which is the (( )) elastic buckling stress. If you know this, the solving the quadratic, the only variable sigma EA, which is unknown, can be computed. So, sigma ET, EK by 2.6 I naught, so gamma in my case, which is the working constant remains 0 because (( )) cylindrical and symmetric. So, this term goes away or only one term here, let me substitute this, 2 10 power 5 k. We already computed in the first step Saint Venant’s constant, so I know all the values.

Now, I know all the values because I have sigma ET here, sigma E eta already computed, sigma EA is unknown in an equation, I naught and A I have already known from the first step. Let me substitute, solve the quadratic and get sigma EA.

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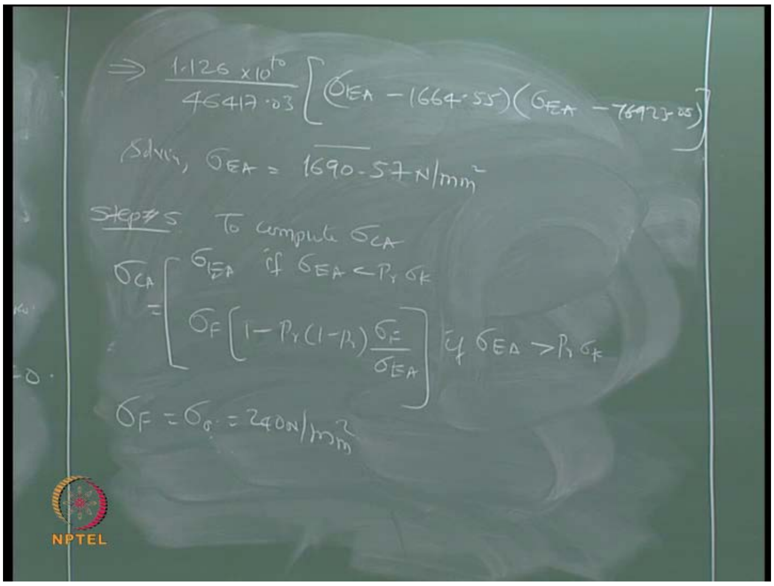

Solving the lowest value, 1690.57…

Step number 5, to compute sigma CA, the critical buckling stress. Sigma CA is given by two equations directly, sigma EA, if sigma EA is less than P r sigma F, otherwise it is given by sigma F of P r if sigma EA is greater than P r sigma F. Now, sigma F can be assumed as sigma naught, which is 240 in my problem.

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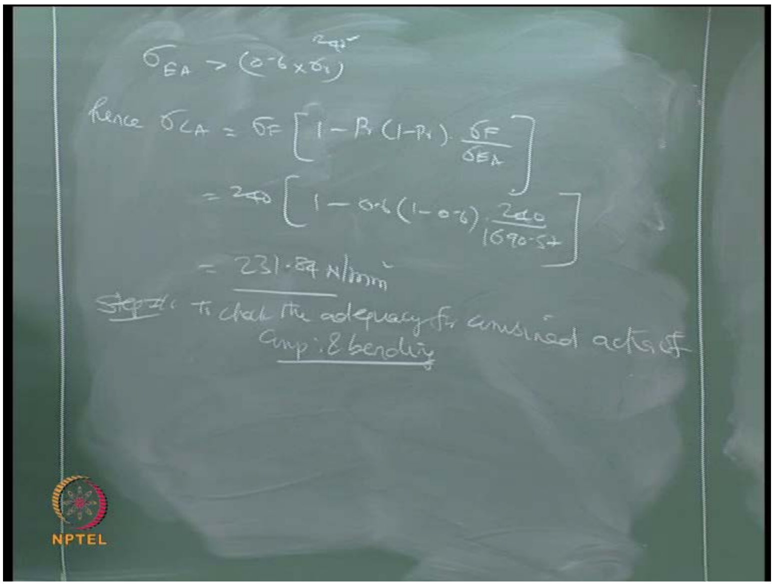

So, naturally, sigma EA is greater than 0.6 of sigma naught. Sigma naught is 240, hence sigma CA is given by the second equation, sigma F of 1 minus P r of 1 minus P r of sigma

F by sigma EA. Substitute in 240 of 1 minus 0.6 of 1 minus 0.6 of 240 by 1690.97, which we get as 231.84. Step number 6, to check the adequacy for combined action of compression and bending. This way the problem is different from the previous example.

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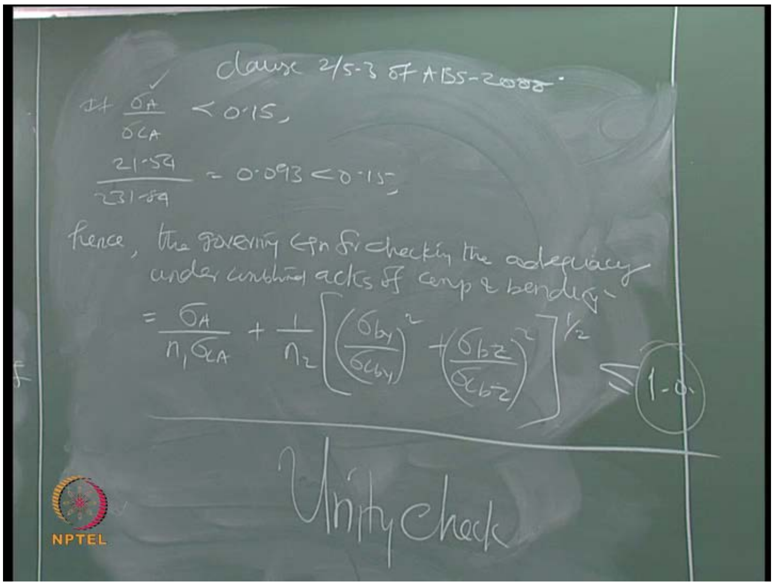

If sigma A by sigma CA, if it is less than 0.15, then the equation is different for checking this adequacy. If it is more than 0.15, equation is different; this is given in the clause 25.3 of ABS-2008. Let us check whether this is satisfied or not, so 21.54, that is what we computed in the first step. Sigma CA just computed, 231.84, this value comes to 0.093, which is less than 0.15.

Hence, the governing equation for checking the, adequacy under the combined action of compression and bending is given by… This should be less than or equal to 1. It was famously called as unity check because all equation, you will see, they are compared to the number unity.

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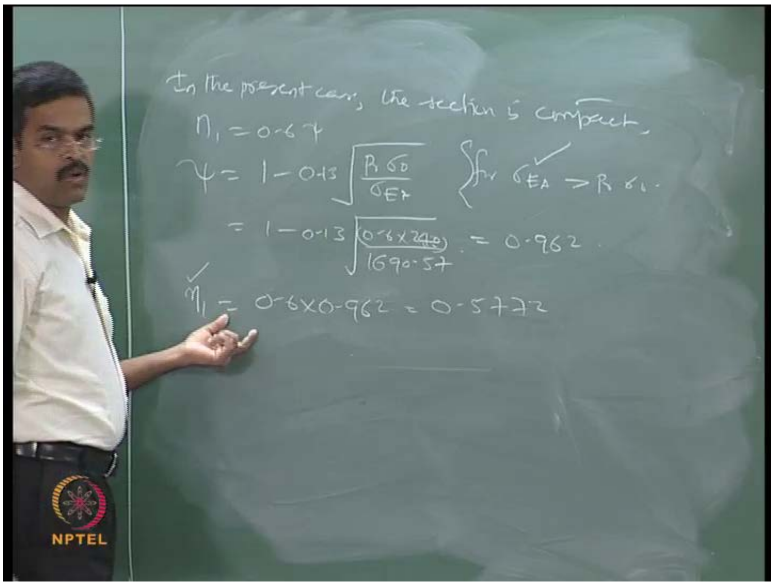

In the present case, the section is compact, we have already established in the first step. n 1 is 0.6 psi and psi is 1 minus 0.13 of this equation because this is true because for sigma EA greater than P r sigma naught. This is the case what we have now, let us substitute here, 1 minus 0.13 of root of 0.6 of 240, 0.962. Therefore, n 1 is 0.6 of 0.962, which is 0.577.

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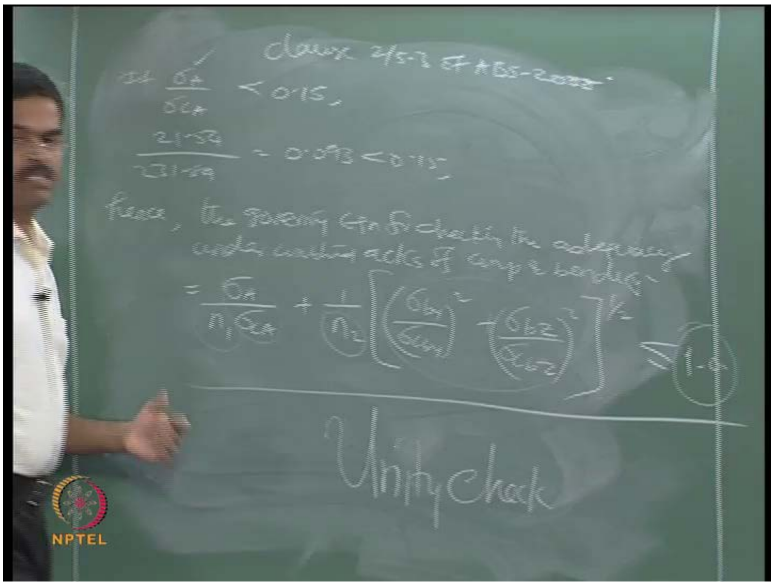

So, I have got two factors now, n 1 is for axial compression, n 2 is for bending because it is the combined action of compression and bending. I have found for the axial compression, now let me do it for the bending also.

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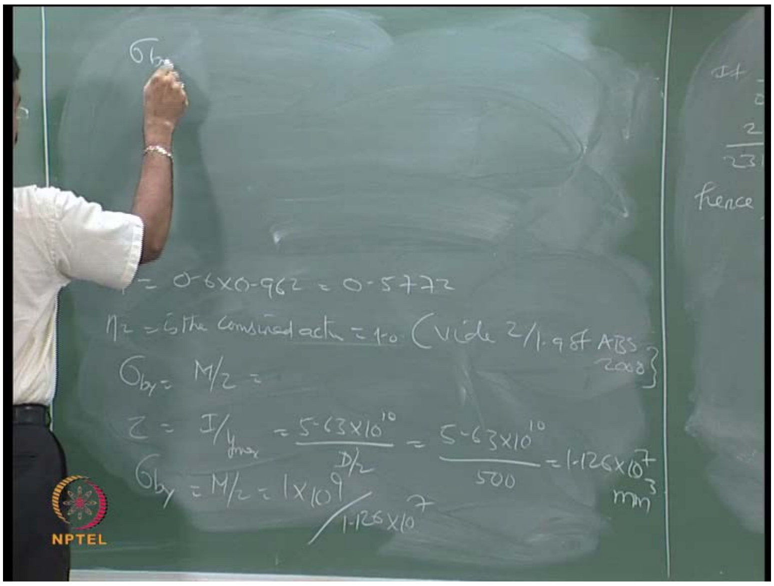

n 2 is for the combined action, which is taken as 1 in this specific case. This is as for clause 1.9 of ABS-2008. Sigma b y, in this equation, is simply M by Z. Let us compute Z as I by y max, in my case, which is going to be… So, sigma b y is M by Z, (( )) Newton meter by 1.126 10 power 7.

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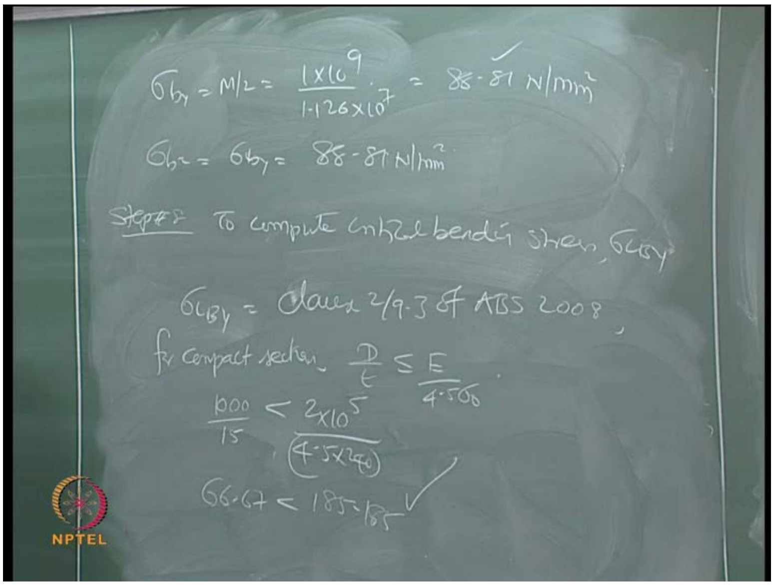

Let us rewrite here again, sigma b y M by Z 1 10 power 9 by 10 power 7, which gives me 88.81 Newton per m m square. Sigma b z in a problem remains same as sigma b y, which is 88.81 Newton per m m square form a problem. I must compute critical bending stress, sigma CBY is given by clause 2.3.

For the compact section, that is, D by t less than or equal to E by 4.5 sigma naught. Let us check this, 1000 by 15, which will be obviously less than 2 10 power 5 by 4.5 of 240 because this value is 66.67. This value, 185.185; so, this condition is satisfied.

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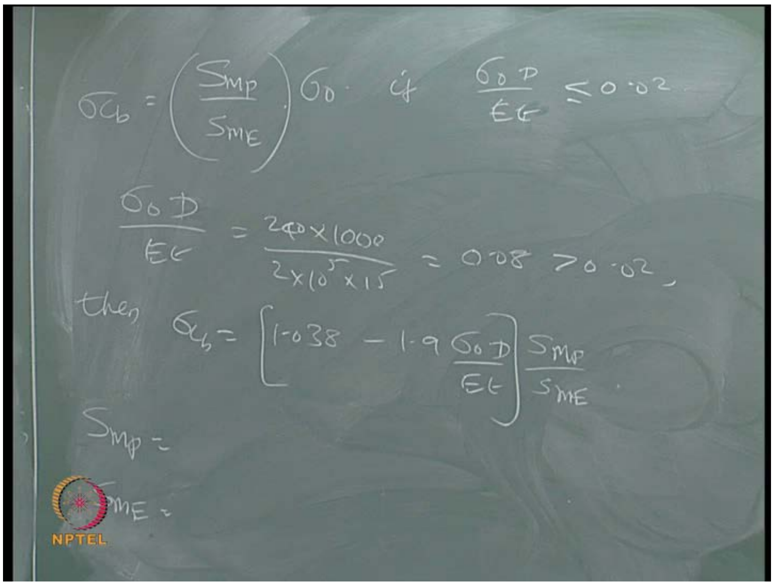

Then, sigma CB is given by couple of equations, which is given by S MP by S ME into sigma naught. If sigma naught D by Et is less than 0.02. Now, let us check this ratio, sigma naught D by E t, in my problem, 240 1000 2 10 power 5 15, which is 0.08, which is higher than 0.02. Then, sigma CB is given by 1.038 minus…

So, let us say, S MP and S ME are the plastic section modulus and elastic section modulus of the given section. If you know the ratio of these two, you substitute here; get my critical bending strength, which is allowed in this section.

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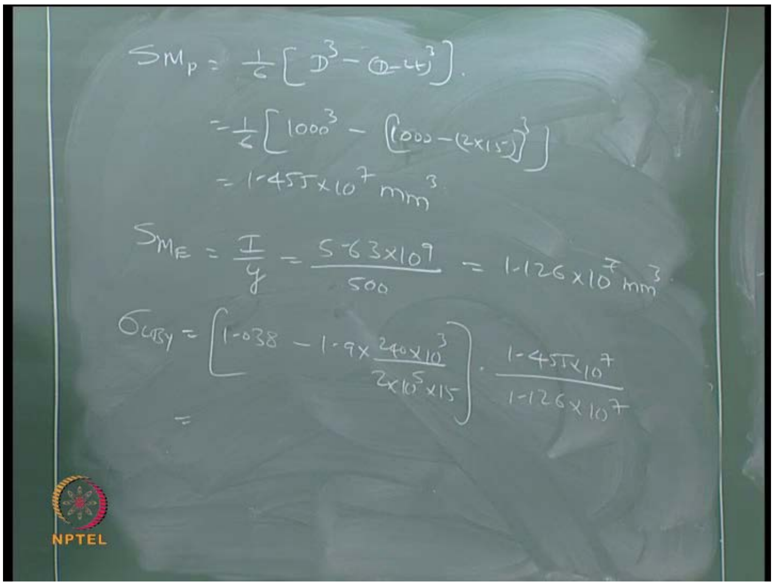

Let me get this S MP and S ME, given by 1 by 6 of D cube minus of D minus 2 t the whole cube. Substitute… S ME, simply I by y, y (( )) by D by 2, I get 500. I have ratios of these two plastic section moduluses, that is, plastic section modules and elastic section modules, substitute in sigma CB. So, sigma CBY is 1.038 minus 1.9 240 into 1000 by 2 10 power 5 into 15 multiply by 1.455 by 1.126 into 240.

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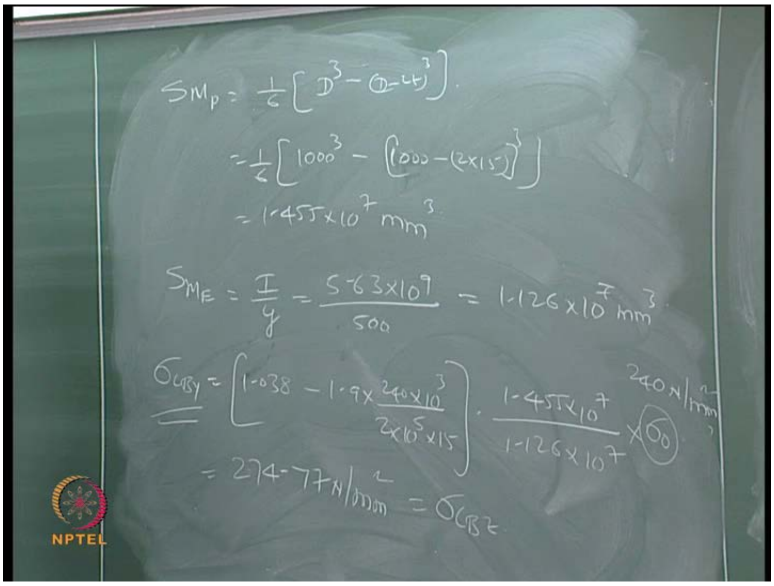

There is a multiply here, I missed out on the last one, so this is into sigma naught. So, the sigma naught is not any problem, 240, so substitute that, get the value as 274.77. It is my sigma CBY; I keep the same as sigma CBZ for my problem.

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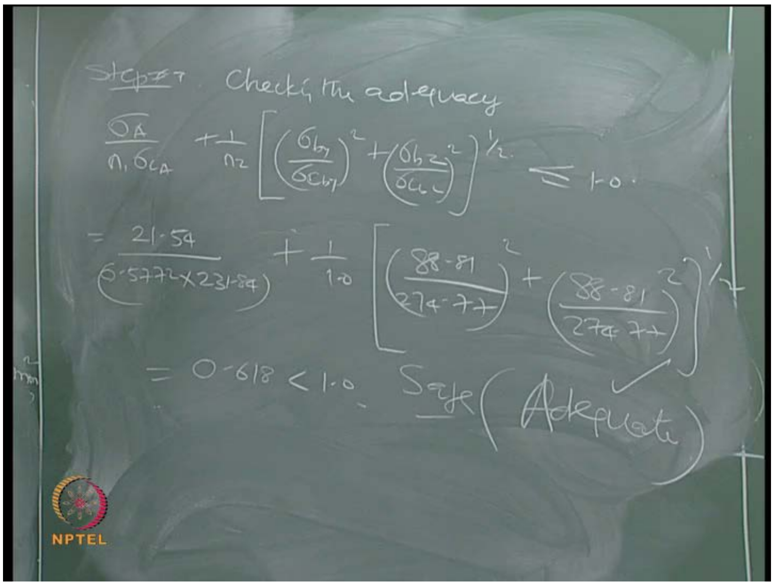

So, last step, checking the adequacy. Come back to the same equation, sigma A by n 1 sigma CA plus 1 by n 2 sigma b y by sigma CBY, permissible value, sigma BZ by sigma CCC, permissible value, raised to the power half. Just check this, this should be less than or equal to 1, that is, the unity check. Let us substitute them, so 21.54 by n 1, already computed, 0.5772 of sigma CA. Sigma CA we have already computed in the last step, which is 231.84 plus n 1 taken as 1, 88.81 sigma b y, already we have computed that, substitute these equations, you get this 0.618, which is less than 1. So, this section is safe or I can say the section is adequate.

So, what I can check in the design for combine action of compressive force is bending or plural action compression with help of these two examples, which has been demonstrated and equation derived in use as from the international course. So, ladies and gentleman, these two lectures, the last one and the current one will help you to look at the uncertainty in the checking process. Adequate process is given for design and we must certainly agree and understand that in offshore structure the design is not done, only the adequacy of the existing assume dimension members are checked. So, once it is safe we consider that the precluding, precluding buckling will not occur. The section will be safe in axial, combined action of axial compressive force and bending. So, we check only for the adequacy, that is, where they overrule certain uncertainties available inherently in the design process.

Thank you very much. In the next lecture we talk about some more advancement in materials and structure.

Thank you.