Computer Methods of Analysis of Offshore Structures

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Module - 01
Lecture – 26
3d Analysis of Space Frame Example – 1 (Part – 2)

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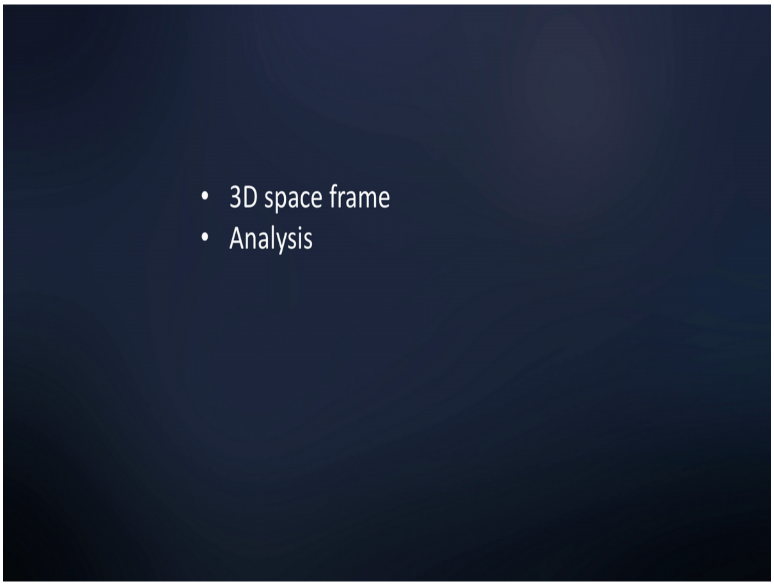

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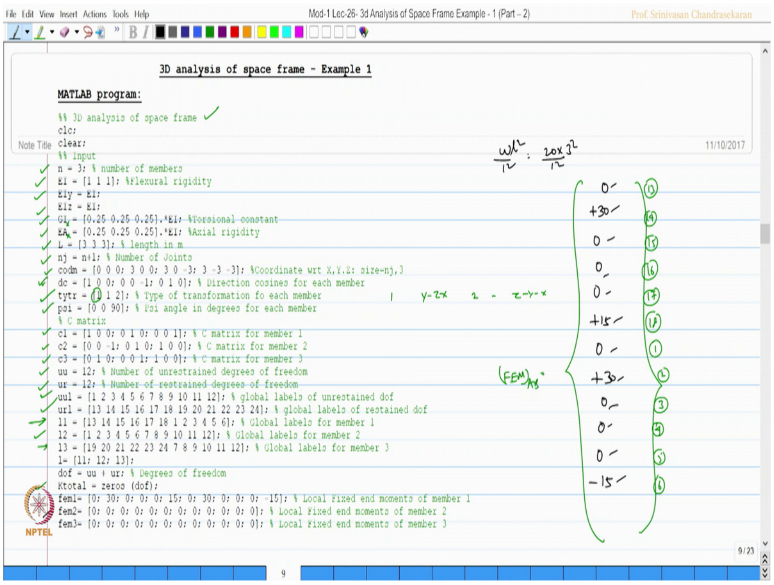

So, the program says it is for 3 dimensional analysis input will be the number of members 3 EI is taken as one for the time being we said, EI y and EI z are EI we also said the torsional constant GI x is one fourth of EI; EA x is also one forth of EI length of the member is 3, we have input number of joints will be number of members plus 1. Let us also work out the coordinate matrix of all the member; we already have it here.

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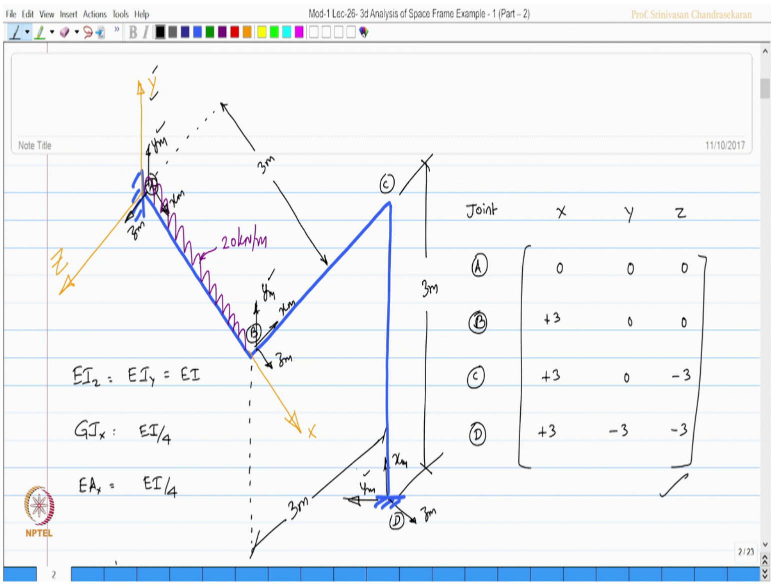

You can see here 0, 0, 0, 3, 0, 0, 3, 0, 3 minus 3 and 3 minus 3, 3 we input that here.

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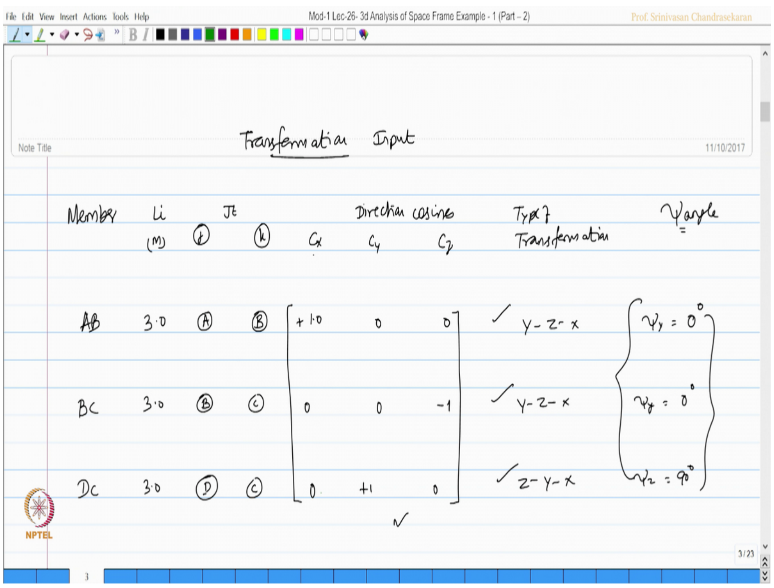

We can see; here we can input this, then direction cosines; we just now worked out; we already have it here; see here 1, 0, 0, 0, 0, 1, 0, 0 minus 1, 0, 1, 0, let us look at here 1, 0, 0, 0, 0 minus 1 and 0, 1, 0. So, no issue; then let us try to find out the type of transformation one correspond to in this; one corresponds to y-z-x transformation and 2 corresponds to z-y-x transformation.

We know for members 1 and 2; it is y-z-x for the member 3 it z-y-x. So, we said 1, 1, 2 psi angle we computed 0, 0, 1, 90, you can see here 0, 0 and 90, we input that 0 0 and 90. Now we know from the C matrix for member 1, 2 and 3; just now we derived this, I will show you for C 1, 1, 0, 0, 0, 1, 0, 0, 0, 1; you can see that here just now we did that C 1.

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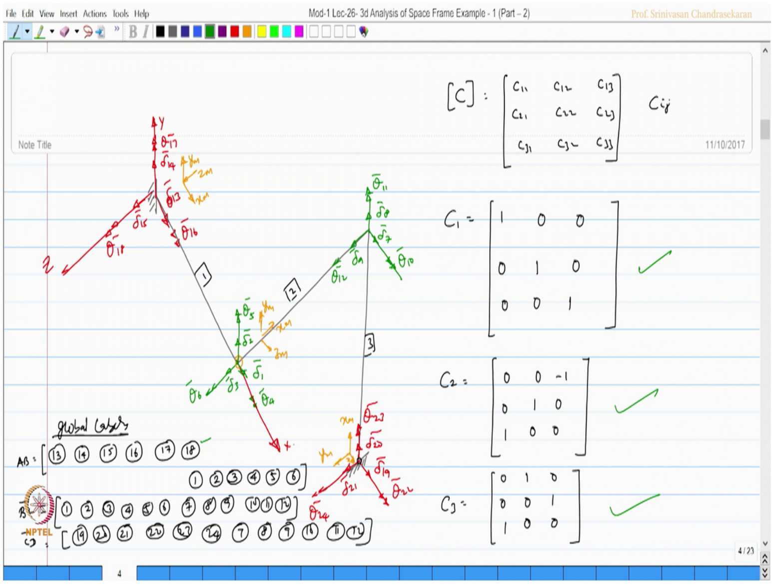

Similarly, C 2 and C 3 the input that here C 1, C 2, C 3.

Number of unrestrained degrees are 12; restrained degrees are again 12, the global label for unrestrained degree you can see here, it varies from unrestrained degrees 1 to 12 restrained degrees; 30 into 24; sorry. So, 30 in to 24; I am going to 12. Now the global labels for member 1; 13, 14, 13 to 18, then 1 to 6, see here global labels 30 to 18, then 1 to 6, we did the same thing exactly here, then for member 2 1 to 12 continuous the member 2; 1 to 12 continuous, then for member 3; 19 to 24, then 7 to 12 for member 3; 19 to 24, then 7 to 12.

We enter that then we form the degrees of freedom, then we found out the fixed end moments you know the fixed end moments are going to be computed based on the loading the loading on the member is only on the member A B. So, the member A B will have moments and the fixed end moments can be simply said as only at the member A B member A B the member has 13 to 6 as the degrees of freedom. So, I can write down here is there fixed end moments of the member A B on labels 13, 14, 15, 16, 17, 18, then 1, 2, 3, 4, 5, 6.

The 13 is along x. So, now, force. So, now, force 14 is along y, there will be reaction the total load applied is 20 into 3; 60. So, 30 this way and 30 up way. So, plus 30 along z no force about x, no force about y no force, but about z; there is going to be reaction moment n, moment w l square by 12. So, w l square by 12 which will be 20 into 3 square by 12 which amounts to 15. So, plus 15 along 1 along x, 0 along y, again plus 30 along z, 0 about x, 0 about y, 0 and this is going to be minus 15.

The members B C and C D; see there are no loads in B C and C D; therefore, the fixed end moments along B C and C D will be 0. Now I assemble this and get the joint load vector. So, we have entered 0, 30, 0, 0, 0, you can check here 0, 30, 0, then 3 0s have to 30, then plus 15 1 0 plus 30, 2 0s, 3 are the 3 0s and minus 15 remaining other members are 0 and 0, then continue with the coding we then form the transformation matrix.

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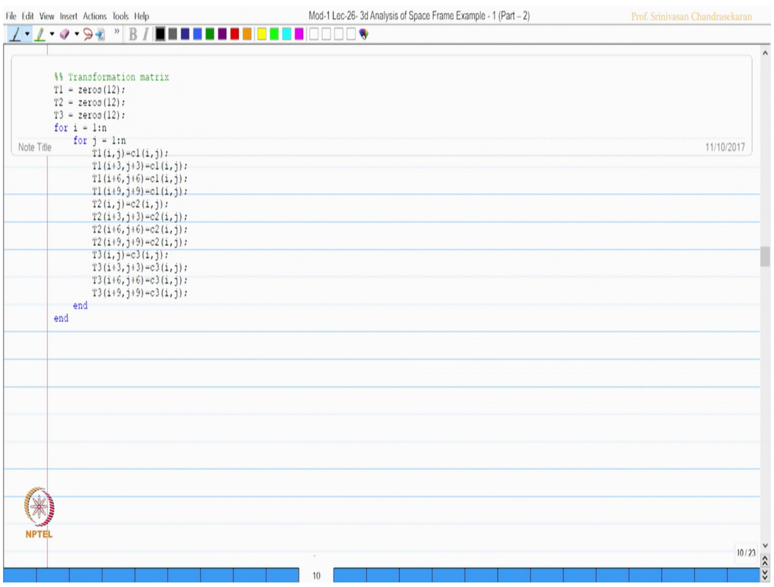

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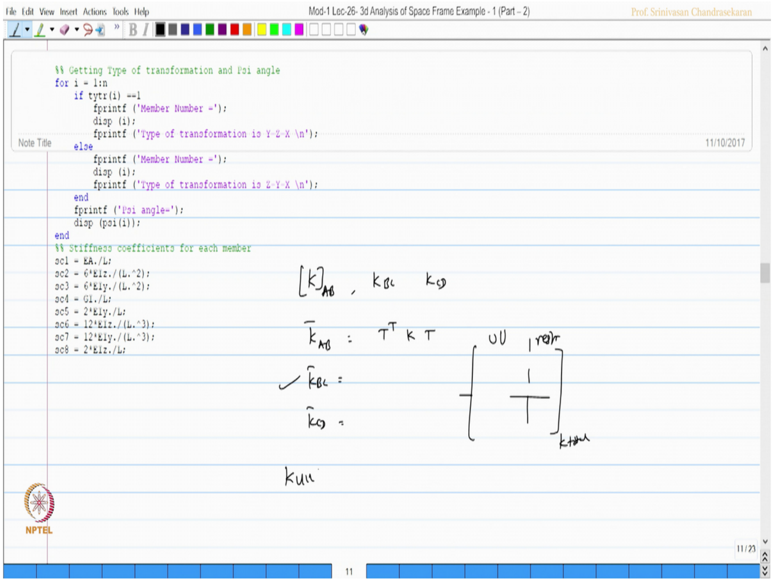

Then we find the stiffness coefficients which we derived in the previous lecture for the entire matrix, we get now the stiffness coefficients and stiffness matrix for the member A B, for the member B C, for the member C D, then we find K global of the member A B which can be T transpose K T of the member.

K bar B C, then K bar C D. Now can be computed we assemble this to get K total in that we partition unrestrained degrees and restrained degrees separately and I can get K u u that is what we have doing here.

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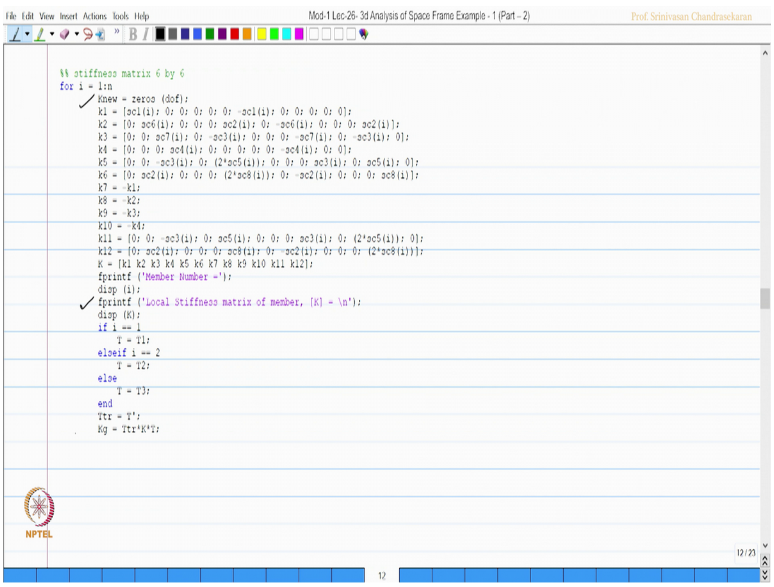

So, K local stiffness matrix, then B said K global that is T transpose K T, then global stiffness matrix for all the 3 members, then compete stiffness matrix.

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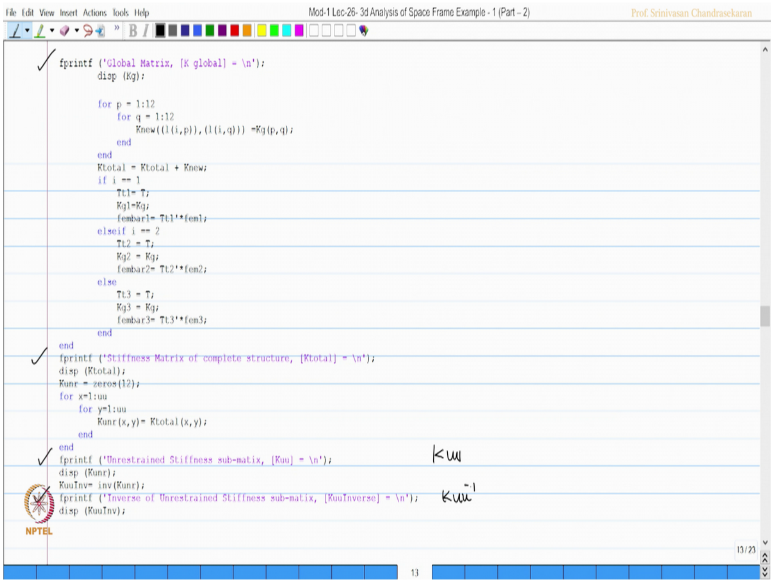

Then from that unrestrained stiffness matrix and inverse of that; so, we get K u u and K u u inverse from these 2 steps.

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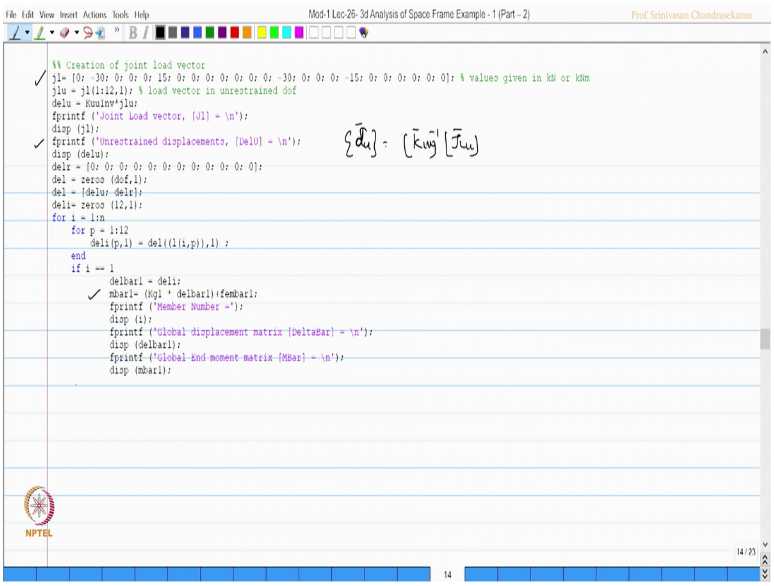

After that we create the joint load vector joint load vector is nothing, but reversal of FEM vector, we crate that vector then we found solved for del u del u is nothing, but K u u inverse of J L u or are in reference axes system I get delta u bar once I get that I get the member forces in global displacements let us look at the 3 members, then ultimately the joint forces you check for this that is the program.

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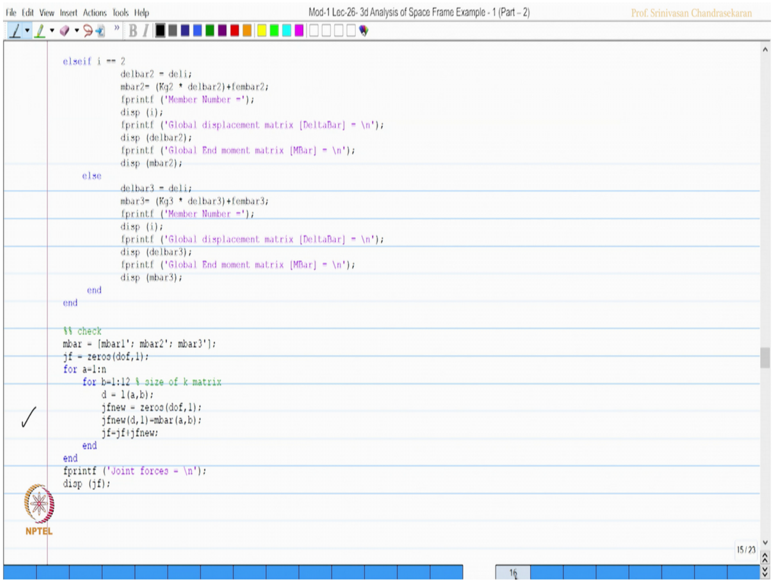

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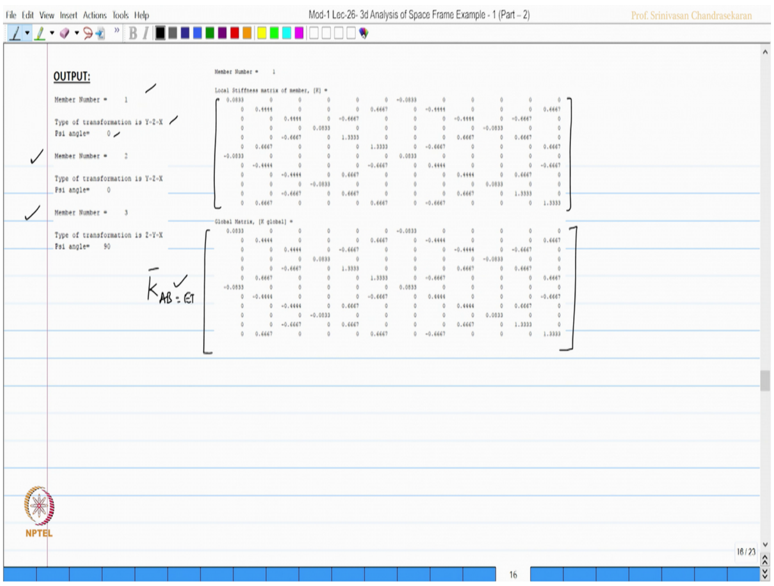

Let us look at the output member 1; y-z-x and psi angle 0 we can see here member 1.

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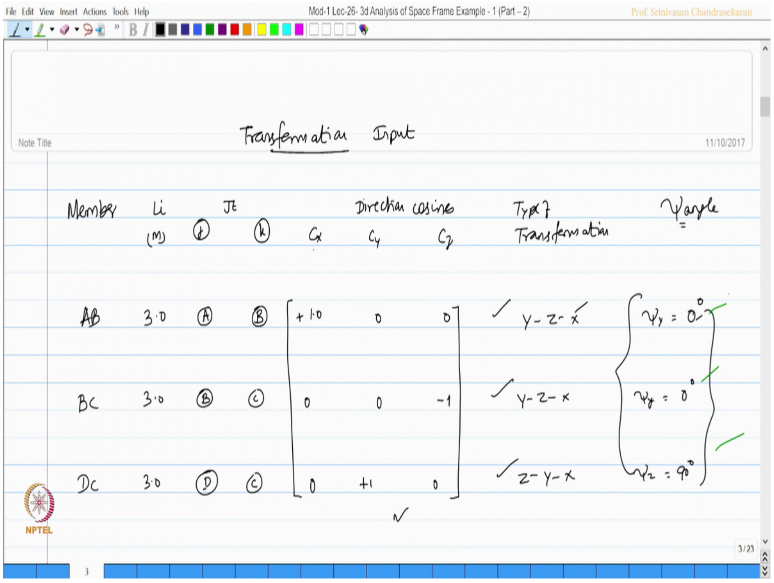

We are going for y z axis psi angle 0.

Similarly, member 2 and member 3; so, that is my local stiffness matrix for member 1 and K bar for member 1, you know the stiffness the rotation matrix for member 1 is identity; therefore, you get exactly K local and K global for the member one as same. So, I get K bar A B now.

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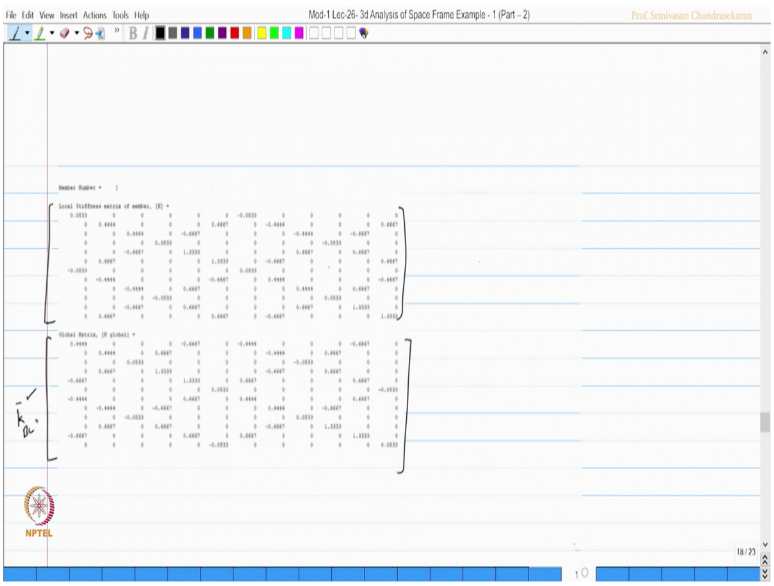

Then I find K local for the member 2 and K global for the member 2. So, I get K bar B C now, then I get K local for the member 3, I get K global for the member 3.

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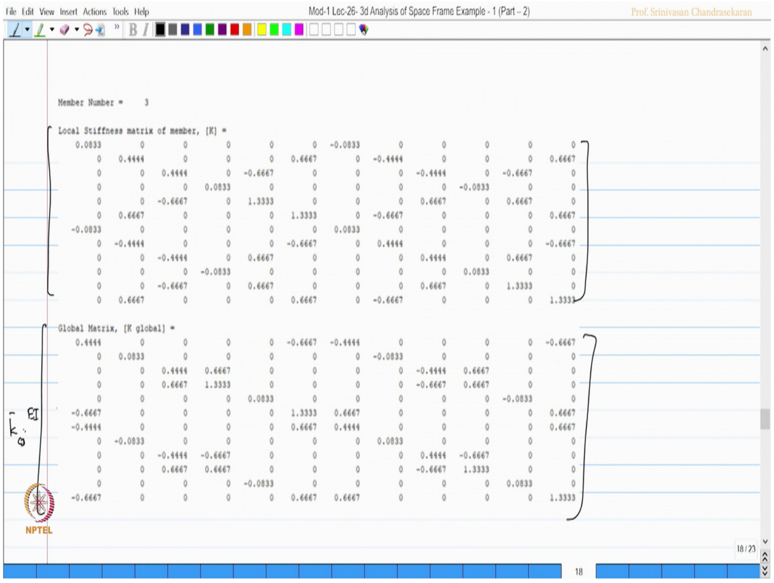

So, I get K bar C D, now we have EI multiplier in all the cases.

I have in EI multiplier in all the cases please understand that EI is taken as unity in this case EI multiplier, then we find the full stiffness matrix.

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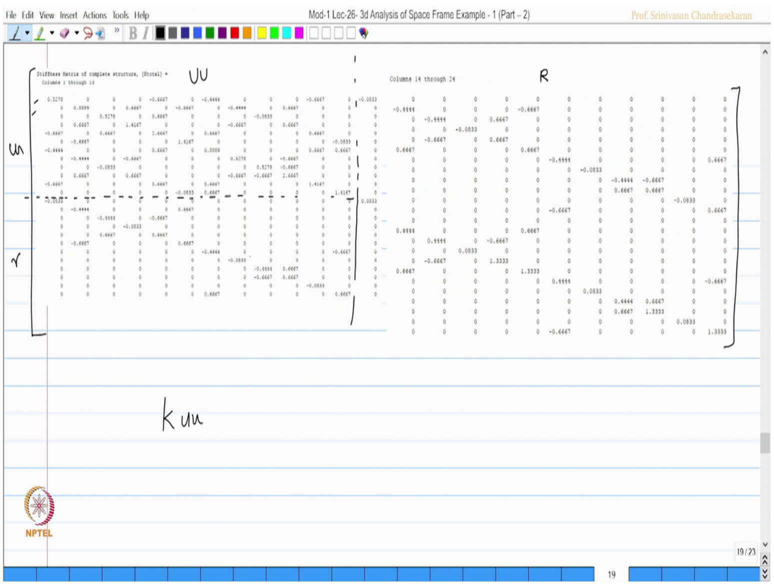

The full stiffness matrix which is going to be 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12 and 24 by 24 full stiffness matrix; we got out of which at 12 first, second, third, 4, 5, 6, 7, 8, 9, 10, 12. So, I have to will be partition here is or not to get s u u and 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12; another partition here correct.

So, this me unrestrained degree this may restrained degree is may unretired degree this may restrained degree. So, K u u will be actually this block the left corner I get K u u.

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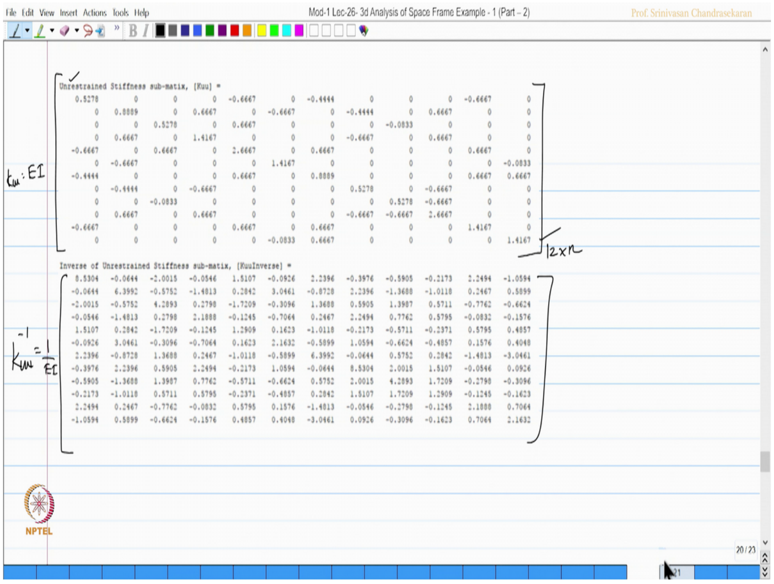

I get K u u which is exactly same what you have here we can check that starting from 0.5278 ends with 1.4167; 1.4167, 0.5278 which is going to be 12 by 12; you can see that 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12; 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 ok.

I take the inverse of this. So, I will get the multiplier K u u inverse I get 1 by EI, here there will be EI out, this is K u u I get inverse, once I get this, I have a joint load vector.

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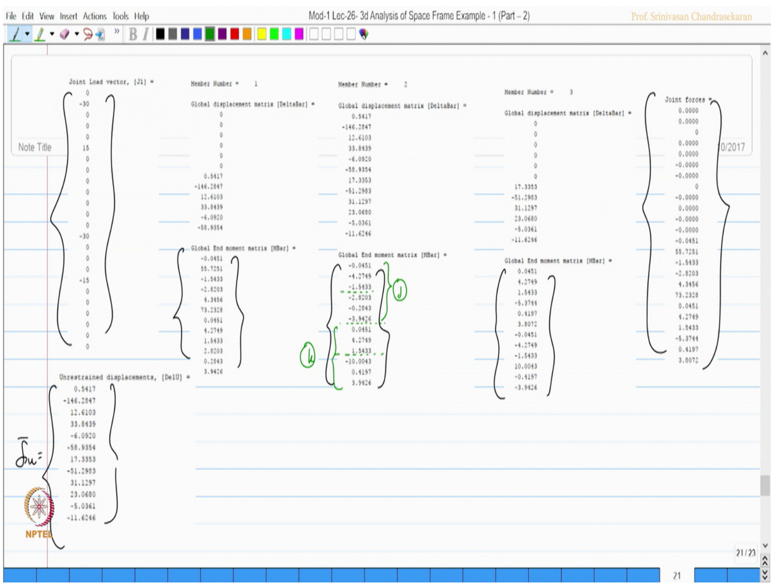

I get my delta u bar as this value, then I substitute run the program get the global values of member 1, member 2 and the end redactions in the entire structure by assembling these 3 which I want to plot and show you. So, let us do it for member wise first member second member and let say third member.

If you look at the first member this is the first member minus 0 point 0 four. So, you can see here very clearly this is along this 3; these 3 will be translational along x-y-z at jth joint this is next 3 will be rotation about x-y-z at jth. So, this is about j th and this is about K th and this 3 will be translation, this 3 will be rotation along x y z respectively let us mark them. So, minus 0.051 means negative let us mark it here, let us mark that here 0.0451.

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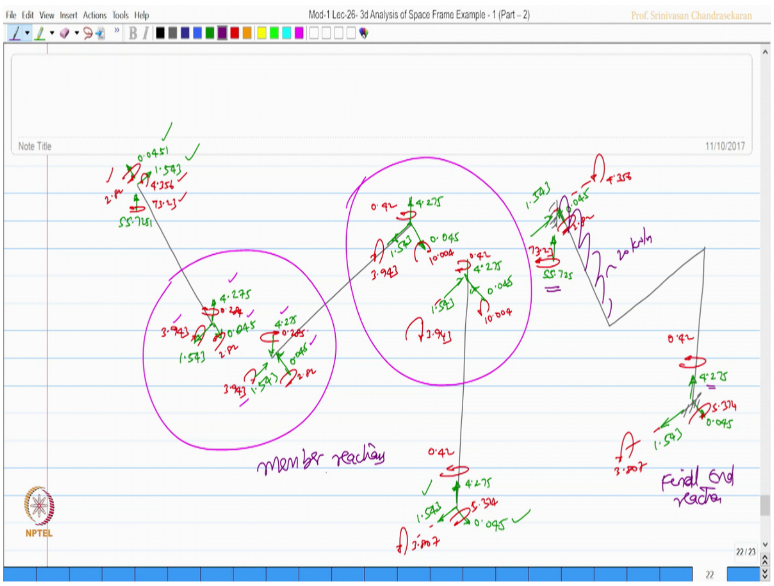

And along y you can see here along y 55.7251. So, 55.7271 and along z. So, negative see here along z is negative minus 1.543. So, 1.543; let us about the translation; let us mark the rotations. So, the first 3 values are now done and next 3 values will be done then the next 3 then the next 3. So, this is for th j the end and this is for the K th end correct. So, minus 2.82. So, minus how do get that put your thumb towards this arrow the remaining 4 fingers we will give you the rotation minus means it is opposite; it should be opposite.

So, it should be clockwise 2.82; similarly, 73.23; similarly 4.356 look at this joint. Now, this is going to be 0.045 and this is going to be 1.543 and this is going to be 4.275 and then the rotations clockwise is anticlockwise 2.82, 0.284, 0.284 and this is 3.943 for the member A B.

Let us do for the member B C this is 1.543 and this is down 4.275 and this is this way 0 0.045 and then the moments, this is 2.82, this is 0.285 and this is 3.943 and for this joint it is going to be 0 0.045, 4.275, 1.543, then 10.004, 0.42, 3.943.

Let us come to this 0 0.045, 4.275 and 1.543, then 5.374, 0.423, 0.807, 4.275, 0.045, then 1.543, 0.42, 10, 0.004, 3.943 one can see here there is a perfect joint compatibility 4.275 4.275.

0 4 5; this way 0 4 5, this way 0.284, 0.285, 9 4 3 9 4 is a perfect joint compatibility in all the joints see here let us also try to plot the end reaction of the whole system which comes like this. So, we get the n values as 55.725 and 4.275, 0.045 and 0.045 which are exactly taken from here, then 1.543 which is here and 1.543 which is here, then 73.23 which is here.

4.356 which is here, then 2.82 which is here, similarly as for this comes in 0.425, 0.374 and 3.807; the total load applied is actually 20 kilo Newton per meter end for 3 meter 60. So, you can see here 55 and 4 makes it 60. So, reaction is balanced and the moments are balanced that is the final n reactions and moments these are members reactions and moments.

So, friends we have discussed in this lecture and interesting space frame problem of 3 D analysis.

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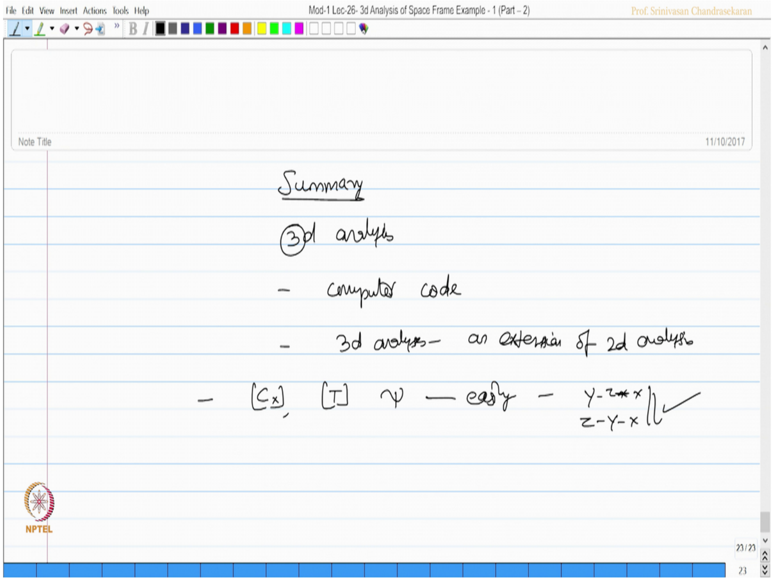

We also discuss the computer code to solve the problem we have understood; how the 3 D dimensional analysis becomes an extension of the concepts the 2 D analysis, we are able to arrive at the transformation matrix we are able to arrive at the rotation matrix we are able to arrive at the psi value easily for a given problem for any transformation chosen for the given problem friends, I want you to do more problems using this computer program and try to compare the results in enjoy how a 3 dimensional analysis using computer course and hand calculations can be very very simple and extended concept of 2 D analysis.

Thank you very much.