Computer Methods of Analysis of Offshore Structures

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Module - 01
Lecture - 27
3d Analysis Example - 2 (Part - 1)

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Let us discuss one more example on 3d space frame structure. In lecture 27 modules 1 of Computer Methods of Structural Analysis Applied to Offshore Structures. In this example we will take a slightly a different problem and try to solve this using computer codes again. I will also give you the computer code and parallel and show you the results as obtained from the output of the computer program directly than compare the results at the end moments on the frame and check for its equilibrium conditions for the applied loads.

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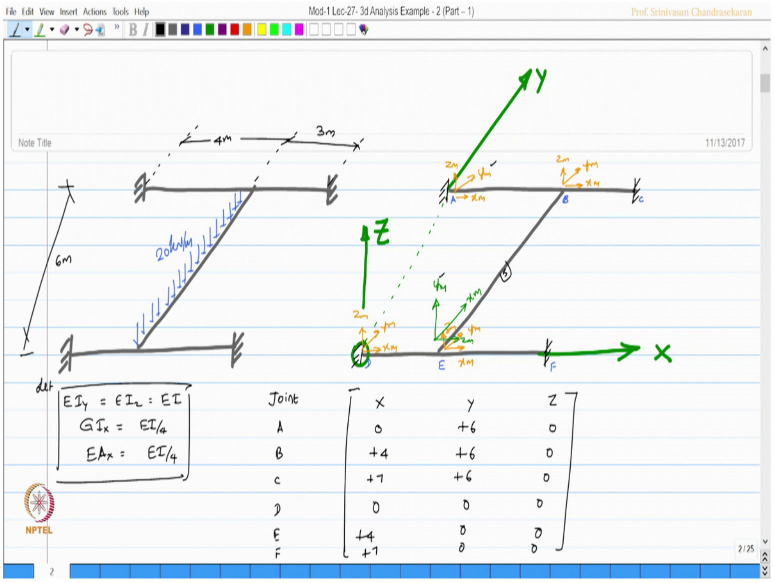

This is my structural system which I am marking. Now subjected to a load; on this member which is about 20 kilo Newton per meter; let us marked the dimension of these say this is 4 meters, and this is 3 meters and this is 6 meters. Let us say EI y is same as EI z is same as simply EI. And the torsional constant GI x is one-fourth of EI. And the axial rigidity constant EA x is one-fourth of EI. So, let us say these constants are available to us in this form.

We want to analyze this, let us mark first the local axis and global axis of this frame. Let us mark the nodal points A, B, C, D, E and F. So, for the member AB the local axis are x m, y m, y m and z m. For the member BC: x m, y m and z m. For the member DE: x m, y m and z m. For the member EF: x m, y m and z m. For the member EB: x m anticlockwise y m and z m ok. Then the global axis is taken the origin here X axis, Y axis and Z axis.

Having said this we can quickly make a table of coordinate systems to understand the joints. Let us make a table, joint and what are the X Y Z coordinates of the joint. Let us say AB C D and E and F. The dimensions are available in the screen now this may origin therefore, A will have X as 0, Y as plus 6 and Z as 0. B will have A as plus 4 meters plus 6 meters and 0. C will have X as plus 7 meters plus 6 meters and 0. D of course, is located at the origin of X Y Z. E will have plus 4 meters and Y and Z will be 0. And F will have plus 7 meters find 0.

So, this is the very interesting input which I require from a computer program. So, I am saving this as it is.

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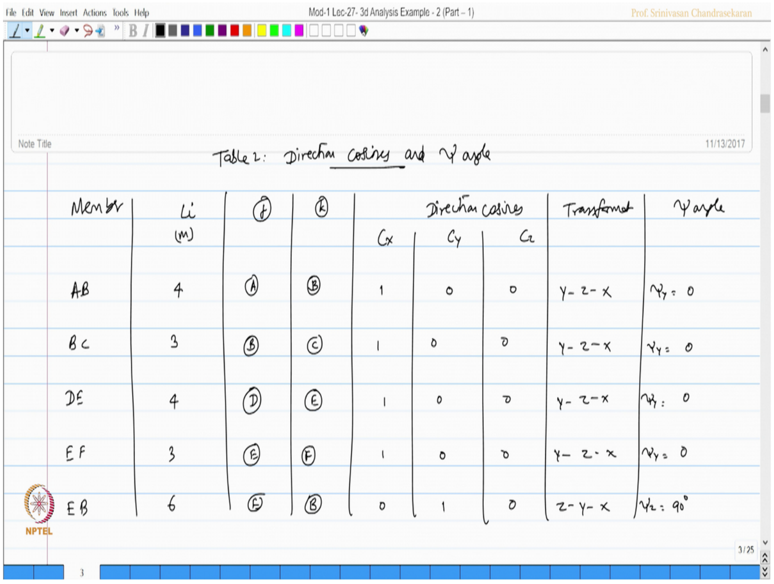
Table 2: Direction cosines and ψ angle

Member	Li (m)	(j)	(k)	Direction cosines Cx	Cy	Cz	Transformed	ψ angle
AB	4	(A)	(B)	1	0	0	y-z-x	ψy = 0
BC	3	(B)	(C)	1	0	0	y-z-x	ψy = 0
DE	4	(D)	(E)	1	0	0	y-z-x	ψy = 0
EF	3	(E)	(F)	1	0	0	y-z-x	ψy = 0
EB	6	(E)	(B)	0	1	0	z-y-x	ψz = 90°

Let us now prepare a table of direction cosines and the psi by angle. This table 2: let us say for the member each member, we need to know the length of the member. We need know where the j and k joints are the member are placed and the direction cosines namely C x, C y and C z, then what is the kind of transformation we are recommending, then what is my psi angle. Let us make a table.

So, there are members AB, BC, DE, EF and EB there are 5 members; AB, BC, DE, EF, AB 5 members are there length of each member is no. So, let us enter these length 4 3 4 3 and 6 meters j and k ends of the members are now marked. So, AB this is BC, this is DE, this is EF, this is EB. Now, what is the direction cosine? It is the angle of x m with x, x m with x x m with x.

You know this is going to be 0 say for cos 0 this one and; obviously, with y and z it will make 90 degree. So, this is going to be 0 this is true for all the remaining 4 members as well, but for the fifth member, if you look at the x m; x m is making 90 degree with x. So, cost 90. So, I should say this is 0 and x m is making 0 degree with y, therefore cos 0 should be 1 and 0. Now if you look at the member AB or BC, DE or EF x m is align with x global, I can recommend any transformation let us recommend y z x transformation for all these 4 members.

So, I will get psi y and for the fifth member you know x is oriented with y therefore, I cannot make y z x I should recommend z y x transformation I will get psi z by inspection. Now what is the angle of psi y? It is actually y m with y. Let us say what is y m with y it is 0 degree, because y m and y are align therefore, this is going to be 0 for all these 4 members. In this case it is y z with y let us say. So, let us talk about y m with y for the fifth member. So, for the fifth member y m is vertical and y is this space so 90 degree.

So, I should say this value is going to be 90 degree. So, there is not difficulty and we need to say this information for the computer program; having said this let us now estimate the C matrix for each member.

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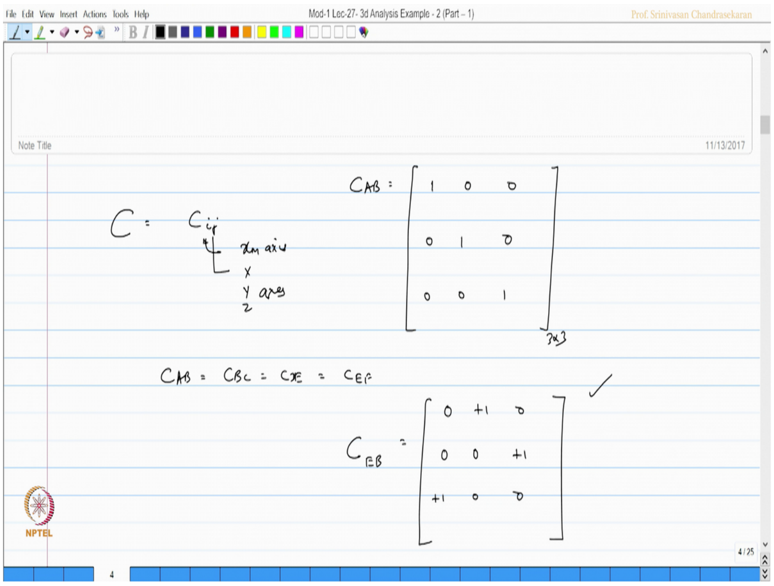

So, C matrix actually we will have c i j, i j; i will represent the inclination or representation of x m axis and this will represent inclination of respective X Y and Z axis with x m. So, let us go for C AB. So, it is going to be 3 by 3 matrix; we know that.

Let us see; what is the inclination of x m with X. So, it 0 so therefore, and y m with Y and z m, so, x m with X 0, x m with Y is 90 x m with Z is 90 therefore, is going to be 1 0 0; similarly y m with X is 0. So, 90 y m with Y is 0 and y m with Z is 90. So, the cosine angles of them respectively will be 0 1 0; similarly if you look at the z m axis; z m axis makes 90 degree with X and Y global, but z m makes 0 with Z therefore, the cosine values of them will be 0 0 1; and; obviously, if I inspection you know the C matrix for the member AB, BC, DE an EF all will be same.

So, I can write this as E equal to. So, C matrix of AB will be as same as BC, DE and EF. Let us do it for C EB that is the fifth member. So, what is the fifth member is located here this may fifth member x m makes 90 degree with X; x m makes plus 0 degree with Y and x m makes 90 degree with Z therefore, I should get 0 plus 1 0 is or not. Similarly let us see y m; y m is makes 90 degree with X 90 degree with Y, but it is plus with Z. So, I should get cos of these angle should be this one.

Similarly, if you look at the z m axis it makes plus with Z and with Y and Z 90 therefore, I should say plus 1 0. Now, I want the C matrix for all members 5 members here. So, this will be also your require input for my problem. So, then based on transformation applied and based upon the members stiffness matrix I can always find the local member stiffness matrix and global member stiffness matrix by following the same procedure, what we had in the last lecture.

For the last example one let us now quickly worked the load vector.

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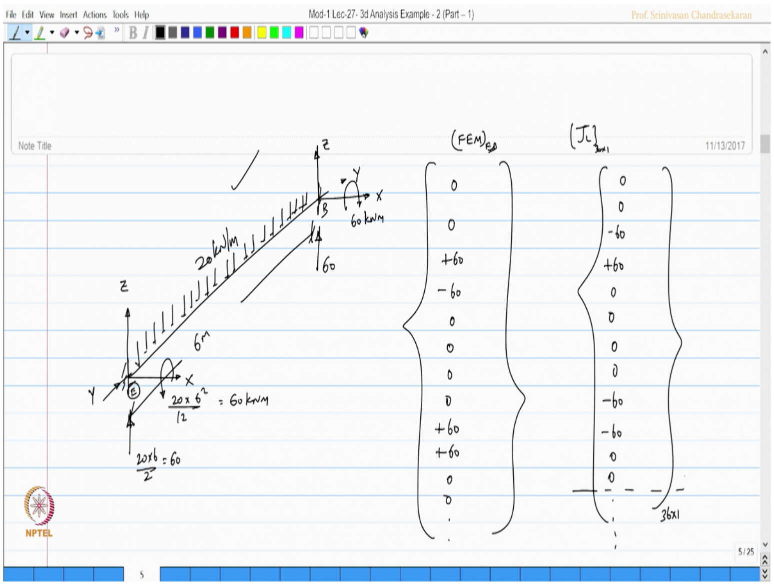

So, this is my beam member, that is; EB. So, apply by a uniform distributed load of 20 kilo Newton per meter for a span of 6 meters is or not. So, I can see here for a span of 6 meters the load is applied. So, I want to work out the joint load. So, let us try to work out the joint load for this. So, I would like to see, what would be the effect of these loads; so marking the axes global axes.

So, you know the global axes are X, Y and Z. So, this is X global, Z global and this is going to be Y is or not X Y and Z. So, if I apply a moment; I will get this value is going to be 20 into w l square by 12 which will make it as 60 kilo Newton meter. And in this way, this will be 60 clockwise. Now the reactions this will be 20 into 6 by 2; which is again 60, and this reaction is also going to be 60; this may positive X, positive Z and positive Y, positive Z, positive Y and positive X ok.

I can now make the joint load vector for the member EB local which will be along X 0, along Y 0, along Z I am making an fixed end moment value, this is the fixed end moment of the local of the member EB. So, this is going to be plus 60. Similarly, the next case 0 0 then minus 60 plus 60 0 0 and so on, so let us now mark the degrees of freedom for this problem.

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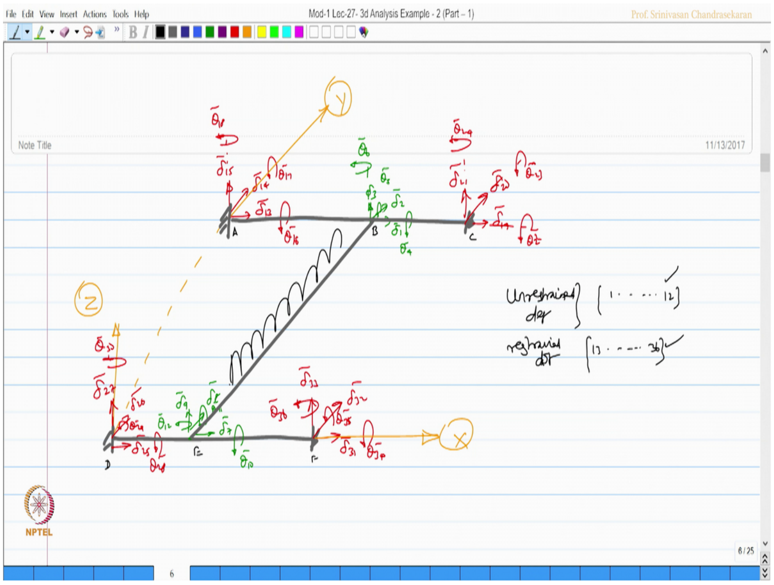

So, the let us have the labels of this. Let us mark the unrestrained degrees of freedom. So, at this joint along Z delta 1 is delta bar 1, delta bar 2 that is; this X, Y, Z this is my capital X, this is my capital Y, this is my capital Z. So, I have to mark the degrees of freedom according to this type. So, delta bar 1 along Y and along Z then the moments. So, I should say theta bar 4, theta bar 5 and theta bar 6; so 6 degrees of freedom here.

Then let us come to this joint delta 7, delta 8 and delta 9, I am putting bar, because they are global displacements. Then rotation 11 and 12, let us now mark the unrestrained degrees of freedom; let us say 13, 14 and 15, 16, 17, 18 then 19, 20, 22, 23, 24 then 25, 26, 27, 28, 29, 30 then 31, 32, 33, 34, 35, 36. So, there are unrestrained degree of freedom which is varying from labels of 1 to 12 and restrained degrees the labels are varying from 13 till 36. There are 6 joints total 36 degree of freedom out of which 12 or unrestrained; remaining all are restrained degrees of freedom. Now, having understood this let us marked the labels.

The labels of the member EB, because this is A, this is B, this is C, D, E and F. So, we are looking for this member, because this member is actually loaded is or not. So, that is what we have here. So, now, let us enter the labels of this very easily; I know we will able to relate these labels very easily with respect to what we have here in the member E and member B with respect to global axis. So, the joint load vector is just reversal of this. The joint load vector if you want to make the joint load vector which will have 36 into 1 which will be let us see for example, the global degrees of freedom.

You know along 1 there is no force, along 2 there is no force. Along 3 there is a force which you get from here, but that is reversed, because these degrees of freedom can be marked very easily; these degrees of freedom can be easily marked. So, along 3 you know there is an upward force, but joint load vector will have reverse. So, let us reverse that. So, by this logic 0 0 minus 60 plus 60; 0 0 0 0; then minus 60 minus 60 0 0 remaining all will be 0. So, it is going to be 36 by 1, I have entered the unrestrained degree loads remaining all there are no loads here, that is the matrix we have. Let us solve this problem.