Advanced Composites

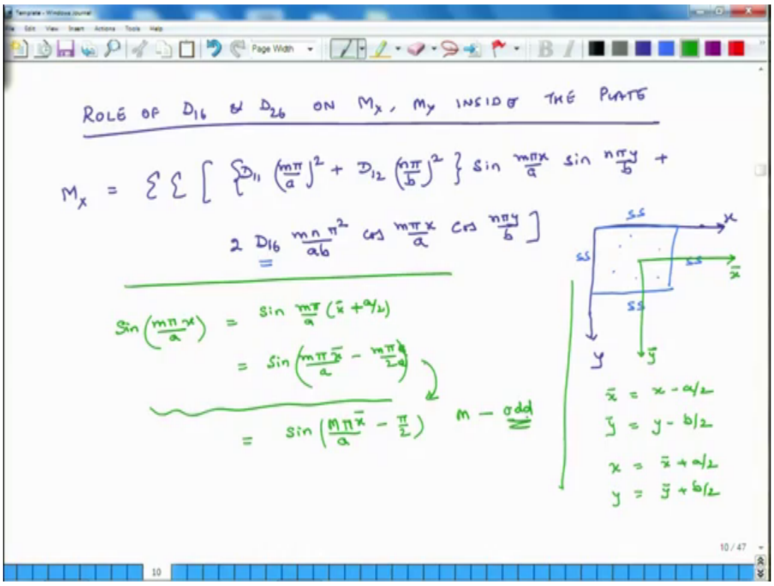
Prof. Nachiketa Tiwari
Department of Mechanical Engineering
Indian Institute of Technology, Kanpur

Lecture - 58
Role of D_{16} and D_{26} Terms on Laminated Plate Response (Part-IV)

Hello, welcome to Advanced Composites, today is the 4th day of the ongoing that is the 10th week of this course. Over last 3 days we have started discussing, we have been discussing the role of D 1 6 and D 2 6 on the behavior of plates and how these terms influence, the solutions which are achieved using formulation such as a special Galerkin or finite element method. And we have seen that in that context h f x become important characteristics, which are heavily influence, because of the presence of D 1 6 and D 2 6. And these terms vanish, when D 1 6 and D 2 6 are not present.

Another feature is something we are going to explore today. The specifically what we are going to see or explore is how does the value of M x or M y for that is sake or for that sake in M x y, how does it change not at the edges, but also inside the plate itself, so that is another thing we will look at today.

(Refer Slide Time: 01:21)



So, role of D 1 6 and D 2 6 on M x, M y inside the plate. So, in the last class, we had developed an expression for M x that M x equals double summation of D 1 1 m pi over a whole square plus D 1 2 n pi over b whole square sin m pi x over a sin n pi y over b plus 2 D

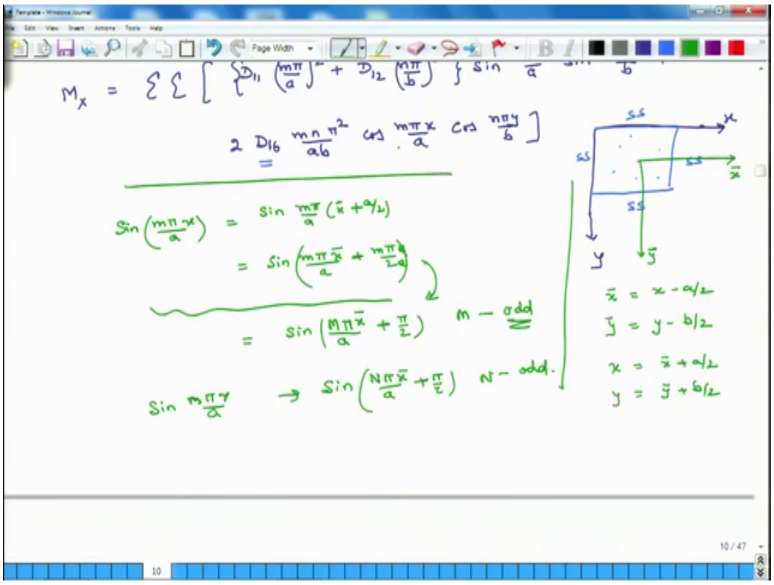
1 6 m n pi square over a b cosine m pi x over a sin not cosine n pi y over b so, this is M x. Now, this relation if you remember was true, if the coordinates system of the plate was located at the corner of the plate, so this is my x axis, this is my y axis and my plate is something like this ok. And it is simply supported in all the 4 sides.

So, what we are going to explore is how does M x change as I move inside the plate and how does it change, and how does it get influenced by this term D 1 6. So, to do that probably a better choice of coordinate system would be, if we have the coordinate system located at the midpoint ok. So, this is my new coordinate system let us call this x bar and let us call this y bar. So, what is x bar? X bar is equal to x plus a over 2 and y bar is equal to y plus b over 2 right or you can say that x is equal to x bar minus a over 2 and y is equal to y bar minus b over 2 so, we do this transformation.

So, all we have to do, if we plug in this, so what does sin m pi x over a, it becomes sin m pi over a into x minus a over 2 right. x I am replacing by x square minus a by 2. So, I have put x bar so, I am sorry so, this is x minus a by 2 minus b by 2 and minus a over 2. So, this will be plus and this will be plus. And this becomes sin m pi x bar over a minus m pi a over 2 a, so, a a goes away right.

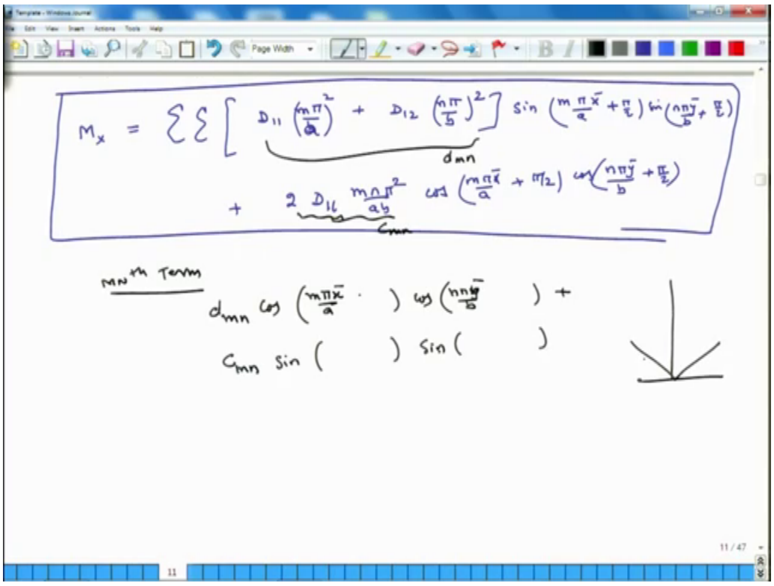
So, anyway, so you can do all this and you can simplify it further and essentially what you will end up will something like this sin m pi x bar over a minus pi over 2. So, from here to here, so here to here if I have to make that jump I have to make one additional, that this will be called begin and this begin is only odd, it is only going to be odd.

(Refer Slide Time: 06:37)



Similarly, I have the same transformation for sin N pi x over a it gets transform to sin N pi x bar over a minus pi over 2 I am sorry and here N is odd. And the same thing can be applied to cosine.

(Refer Slide Time: 07:11)



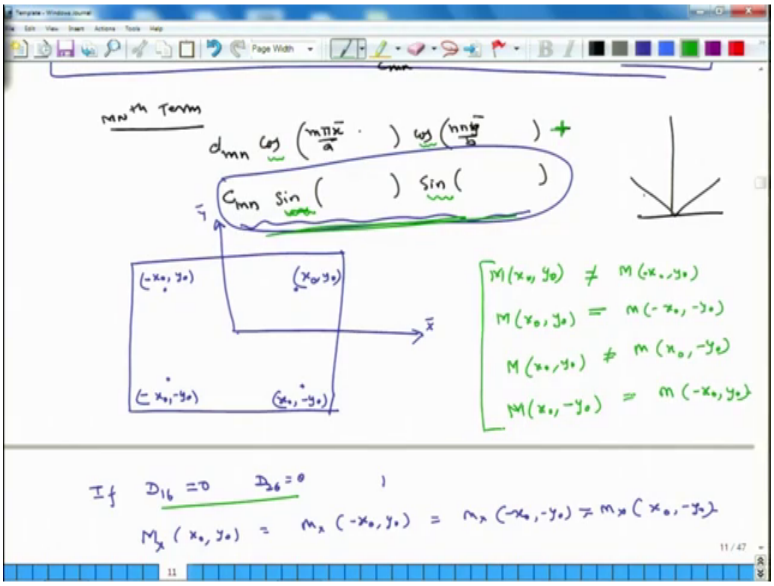
So, if I have if I shift my coordinates system to the centre relationship for M x, it becomes D 1 1 m pi over b, so will be m pi over a whole square plus D 1 2 n pi over b whole square sin m pi x over a excuse me minus pi over 2 sin n pi x over b minus pi over 2 plus 2 D 1 6 m n pi square over a b cosine m pi x over a also this should be plus.

Student: Into x bar.

Pi over 2 cosine n pi x bar over excuse me so, I have made a mistake here, it should be y. So, n pi over y bar over b plus and here also I should have y this is here so, this is the transform relation. So, let us now look at this a little more carefully. And what does it mean? So, so let us call this entire thing as d m n and this entire thing is c m n.

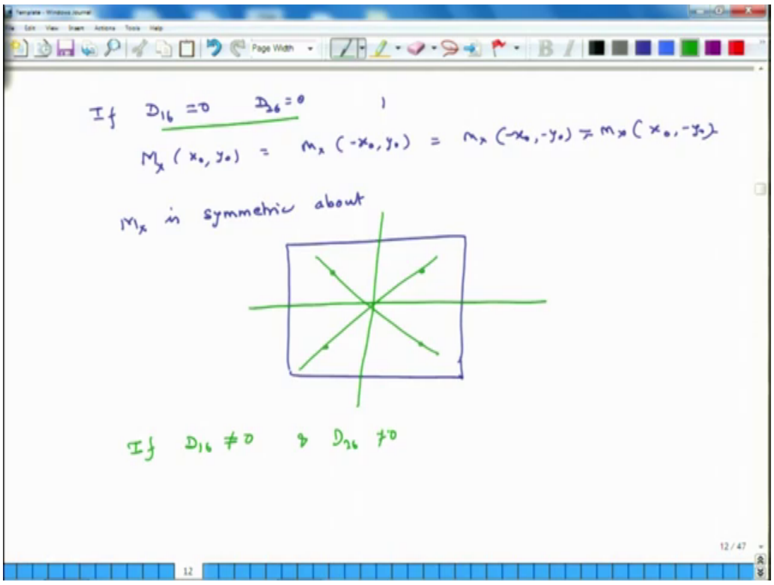
So, the MN th term, what is MN th term? In for the MN term what will be have we will have d m n sin m pi x bar over a plus pi over 2 sin n pi y bar over b plus pi over 2 plus c m n cosine this times cosine this. And what is so, what is sin m pi x plus pi by 2, what is sin theta plus pi by 2, it is sin theta plus pi by 2. So, you have sin you have theta and then you have, so it is cosine theta. So, this is cosine and I can remove pi over 2 from here and same thing here you know and this is sin and negative gets multiplied so, it becomes so, pi is gone.

(Refer Slide Time: 11:23)



Now, let us look at the plate geometry again. So, a plate geometry is this; the origin is now at the centre. Consider a point or let us for purposes of convention just for this lecture only. So, this is x bar and this is y bar. So, consider a point x naught, y naught and consider a point minus x naught minus y naught same point, but on the other side and then the third point is this is what which one minus x naught y naught and the fourth point is x naught minus y naught ok.

(Refer Slide Time: 12:25)



So, if D 1 6 was equal to 0 and D 26 actually D 2 6 for m x does not matter, but D 1 6 and D 2 6, where 0 then M x, so that was 0 then what would happen this term will go away, because this is related to the D 16 term. This is related to D 1 6 term this term will not exist so, the only term is maters is cosine term.

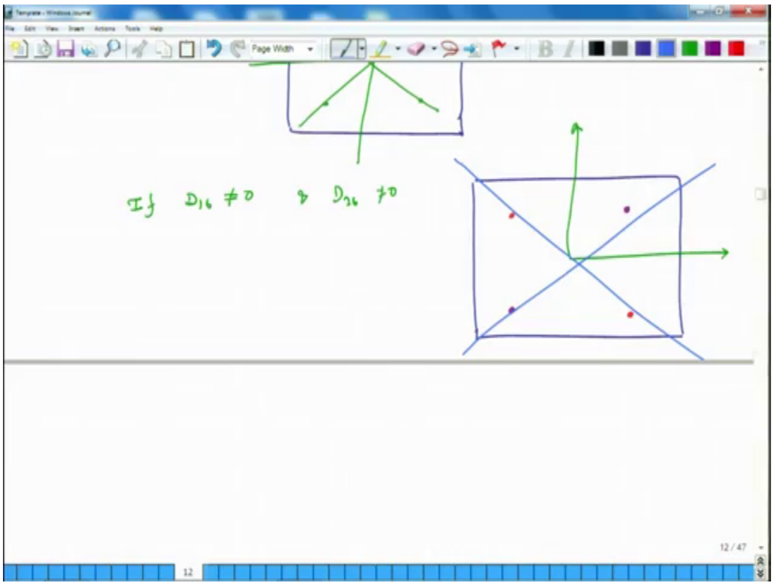
And so and cosine instead of x naught I got minus x naught it does not change, instead of y naught I could minus y naught it does not change. So, what it means is that M x at x naught y naught is equal to M x at minus x naught y naught is equal to M x at x naught minus y naught is equal to M x at x naught minus y naught ok, which means that M x is symmetric about so, it is symmetric.

So, this is the plate then what are the planes of symmetry, this is one plane of symmetry, this is another plane of symmetry this is so, these are the two planes of symmetries. And this is another plane of symmetry and this is another plane of symmetry. So, this is how if D 1 6 and D 2 6, so whether the point is here or here or here or here does not matter the value of M x is going to be same.

Now, if D1 6 is not equal to 0, then what happens and D 2 6 is not equal to 0. Then we also have to consider the sin term ok. And in that case what we find is, so if I replace x by x naught this cosine term does not change this cosine term does not change, but this thing becomes negative, because sin of minus x is (Refer Time: 15:08). So, what that means is that M x naught y naught is and these things are added up these right.

So, here something the sum will change so, this will not be equal to M minus x naught y naught what else M x naught y naught. Now, if I change both x and y both to their negative values, then this negative and this negative will multiply, so this m x naught y naught will be same as M minus x naught minus y naught. And the last thing is M x naught y naught for the same reason will naught be equal to M x naught minus y naught. And finally, we can say that M x naught minus y naught will be equal to M minus x naught y naught so, these are there.

(Refer Slide Time: 16:37)



So, this is what happens, when D 16 and D 26 are not 0. So, in that case if I have a plate and this is my origin then a point here. We will have the same moment as a point here and the point here will have a same moment as a point here. So, the planes of symmetry in this case are what are the planes of symmetry? See the planes of symmetry are these. In this case we had more planes of symmetry, but here we have planes of symmetry only along the diagonal. Here, we have along the diagonals as well as along the lines, which are cutting through the mid of the plate on both sides.

So, this is something very important to understand and because of this the plane also the plate also it starts twisting plane also starts developing twist curvature, because the movements are not symmetrically distributed along the origin. So, this is another thing I wanted to share with you, and that closes our discussion on the treatment of D 1 6 and D 2 6. Tomorrow we will start a new topic, which will be related to vibrations of these types of plates and dynamic equilibrium in these types of plates. So, that closes our discussion for today and we look forward to seeing you tomorrow.

Thank you.