Introduction to Composites

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Lecture – 41
Failure Modes of Composites Materials

Hello. Welcome to introduction to composites. Today is the fifth day of the ongoing week and what we plan to do today is extend our discussion related to different failure modes of unidirectional composites. Till so far, we have discussed 2 scenarios; one is what happens to a composite when it is subjected to longitudinal tension and what happens to it when it is subjected to longitudinal compressive load.

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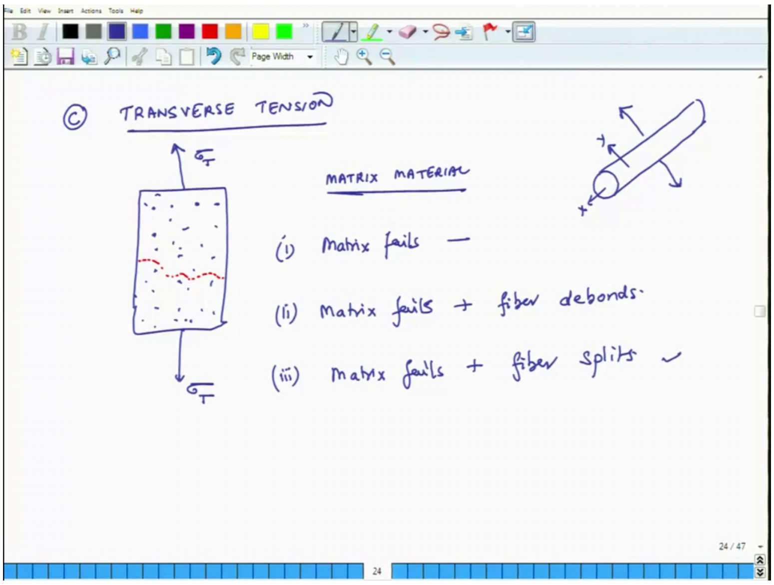

So, today, we will discuss three more scenarios. So, the third one is transverse tension. So, you have a composite sample and I am applying it some tensile load on it, but it is transverse reoriented. So, if what; that means, is that the fibers are aligned at a ninety degree to the external load now when this is the case, we have discussed this kind of a situation earlier also and here the most important thing which decides when this thing is going to fail is the matrix material ok.

Matrix material that is the most important parameter if the matrix is really strong then you can it can take a lot of load otherwise it will take less load and that nature of failure are of 2 types. So, the first nature is that either the matrix fails and that is it is nothing else happens. So, when matrix fields what could happen just the matrix is failing then suppose. So, this could be the surface along which the failure happens.

So, no damage is happening to any fiber or the interface of the material now this will be true if the bonding between the fiber and the matrix is really strong and the number of fibers is not extremely large then this failure surface can pass through the entire thickness of the sample without running into a fiber the other scenario could be that matrix fails and along with it the fiber debonds. So, when the matrix is filling, it is also and let us say fiber is partly wetted and it is partly bonded to the matrix then the fiber debonds from the surface. So, that is another situation.

And the third and that is an extreme situation is when the bonding between the matrix and fiber is really good and there are a lot of fibers in the thing and the fiber is itself very brittle and prone to cracking then what can happen is matrix fails and plus fiber splits. So, the fiber itself could be split and it can tear off into 2 pieces and that can happen especially when the strength of the fiber is not that high especially in the transverse direction.

So, suppose you have a fiber here, when I am applying sigma T, it is this is the direction in which the stresses it is experiencing and this fiber will have strength in the length direction. So, let us call this x and in the other direction let us call this y if the strength of this fiber is not that high in the y direction, then it could split it is split and this third scenario could happen.

So, this is the third case related to different loads.

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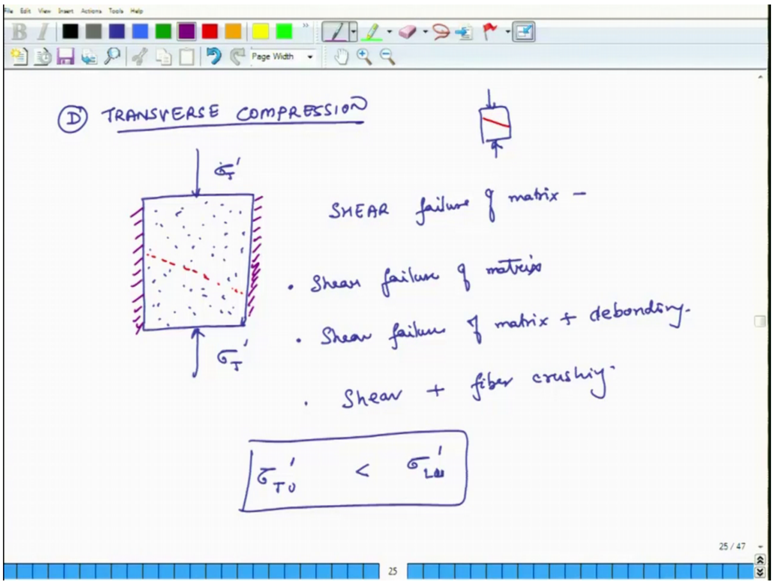

The next one is transverse compression transverse compression. So, again let us see how it looks like. So, I am applying a compressive force the consequential stress is sigma T prime and it is transversely oriented. So, the fibers are running parallel actually normal to the surface of this board.

Now, here typically when we apply a compressive strain a stress to appear isotropic material; suppose, you have a pure isotropic material and you apply a compressive stress a lot of times what happens when it feels it fills along a shear plane. So, same thing can happen in this case, it can happen; it can fail along a shear plane.

So, here shear failure of matrix this is the dominant feature and again you can have 2 or three scenarios one is shear failure of matrix. This is one scenario the second scenario is shear failure of matrix plus debonding and the third one is shear failure plus fiber crushing. So, the fibers can we also get squished.

So, that is there; now typically sigma T u prime tensile no transverse ultimate strength of the composite in the compressive direction is substantially less than sigma L u prime this is important to understand. So, this is the typical case, unless you have some lateral constraints on the material. So, this is typically the case, but if you suppose somehow constrain it on these lateral sides, then it has nowhere to go then sigma t u can become higher than sigma L u prime ok.

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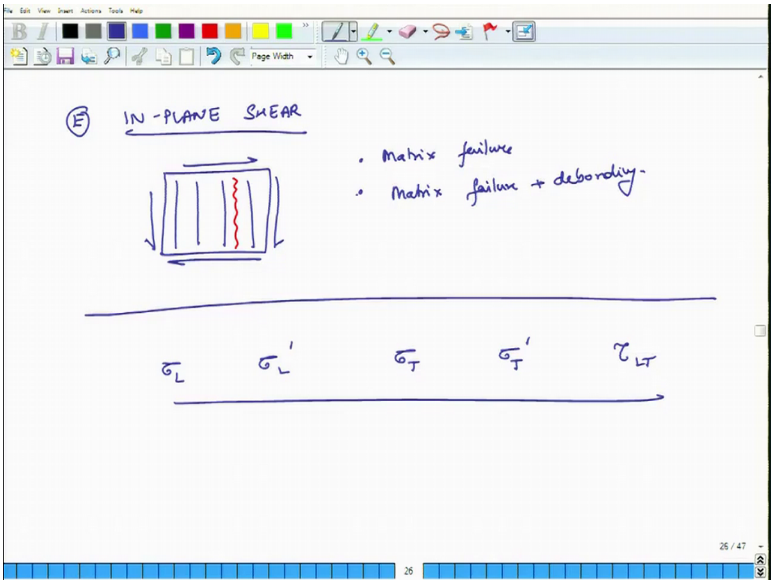

So, this is another scenario and the last failure scenario related to external loads which we will discuss is case E in plane shear in plane shear. So, you have a situation like this; let us say by fibers are oriented like this. So, it is subjected to an external shear and what could happen is it can have a failure along a particular plane.

So, typically here the matrix fails or you have matrix failure plus debonding plus debonding the fiber tends not to break because it has a very high strength. So, most of the failure happens between 2 fibers along the whole length of it. So, either the fiber can get debonded, but it will be a very very rare thing that the fiber itself starts breaking. So, these are the 5 scenarios which we have discussed in first case we had applied sigma L, second case; we had applied a compressive longitudinal stress, third case, we had applied transverse stress in the tensile direction fourth case it was transverse compression and the fifth case was tau L T.

So, these are 5 scenarios which we have discussed and associated with these scenarios, they are different modes of failures which we have discussed which is important to understand and realize when you are designing composite structures going forward, we will move to a different situation and there are several other properties of composite materials which we will discuss and how to predict them. So, some of these properties are thermal coefficient thermal expansion coefficient ok.

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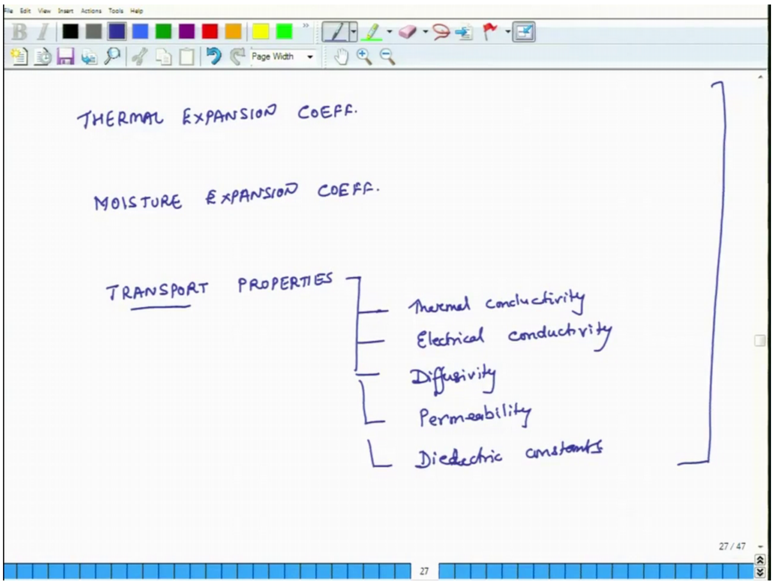

So, here the question is that you have fiber you have matrix fiber move expands at a different rate matrix expands at a different rate what is the overall expansion coefficient of the composite then the other thing is moisture expansion coefficient. So, what are we trying to do in this situation, typically, a lot of matrix materials a lot of matrix materials they expand when they are exposed to moisture they absorb moisture and then they bloat they expand and composites are mixtures of matrix and fibers. So, when you have a mixture of fiber and matrix if it absorbs some moisture how much does it expand by.

So, we will have a relation for that then we will have transport properties. So, this is a general term in transport properties what are their several properties first is thermal conductivity then electrical conductivity then we have diffusivity then we have permeability magnetic permeability and electric permeability and we can also have dielectric constants.

So, we will look at different rules and relations which can be used to predict all these properties because once we have this idea, then we would have truly learned how do unidirectional composites behave right and then maybe starting next week, we will move to the next stage where our focus will be if we have several layers of these unidirectional composites tagged up in a laminate how does the overall laminate behave. So, this is what we plan to do tomorrow and tomorrow is also the last day. So, this is what we plan and then we will also do a couple of examples and then summarize the whole thing. So, that concludes our discussion for today. Till then; till tomorrow have a great day and I look forward to seeing you tomorrow.

Thank you.