Advanced Composites
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Lecture - 02
Different type of Fibres

Hello, welcome to Advanced Composites Course. Today is the second day of the first week of this course. And what we will discuss today is different types of fibres and whiskers, which are used in composites for reinforcing the material.

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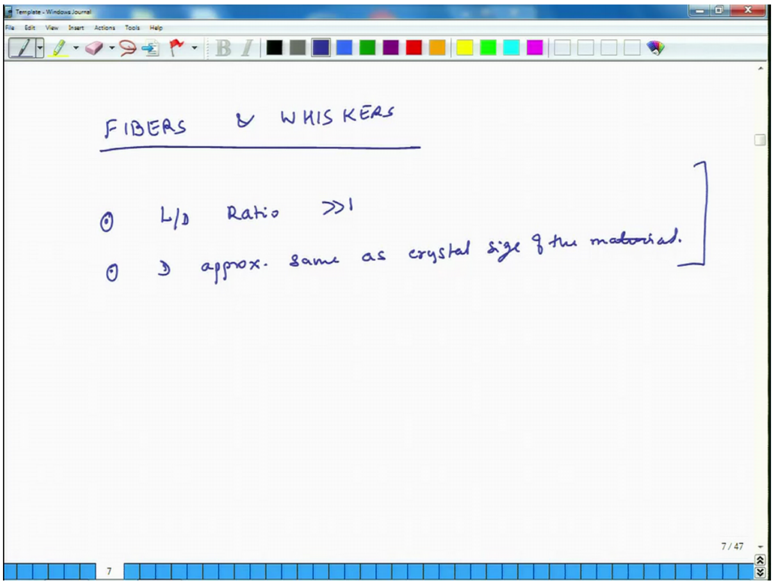

So, I used these two terms fibres and whiskers. So, first we will discuss what are fibres, and then very quickly we will also this term known as whiskers. So, what is fibre? It is, so we can have different types of fibres in composites, we can have glass fibre or graphite fibre, Kevlar fibre or we can have metallic fibres that are fibres made up of steel or titanium and so on and so forth. But if we have to define fibre, then what is fibre, it has two features one is that its length to diameter ratio L by D ratio is very very large compared to 1.

So, you have a diameter and may be several thousand times if it is the length, then you have you call it a fibre. And, but it does not mean that you will you can have any diameter ok. So, a rod will also have a large L by D ratio, but then the diameter has to be sufficiently small. So, diameter should be approximately same as crystal size of the material. So, it has to be sufficiently thin. So, a rod is not same as a fibre even though it has a very large L by D ratio, but it the diameter has to be fairly small.

And the fact and when the diameter becomes approximately same as that of the crystal size, then what we start seeing is that the strength of the fibre starts improving significantly. And the reason is that if you have a thick fibre let us say its diameter is 5000 times the crystal size, then you may have several crystals lying along parallel to each other, and there may be a lot of defects between different crystals. And as a consequence of these defects, the bond between these crystals which are parallel to each other in the thickness direction they may be very weak. So, if you pull the thing it may rip off and it may break.

But if the diameter starts approaching the crystal size, then all the crystals they start aligning with each other very well, and they are connected with strong molecule intermolecular bonds or at crystal level. And as a consequence, the breaking strength of the fibre is significantly larger than the breaking strength of the same material, but which is available in bulk form.

So, you may have a glass fibre, and it may break at a particular stress level. And you consider the same glass in a bulk level, and you will find that it fails at a much lesser value. And sometimes the ratio of this strength could be as much as 200 to 1000. So, this is an important observation which we look at and we take advantage of. So, if we use lot of fibres essentially if I use a lot of glass fibres, I may get a composite which may be stronger than glass bulk material itself.

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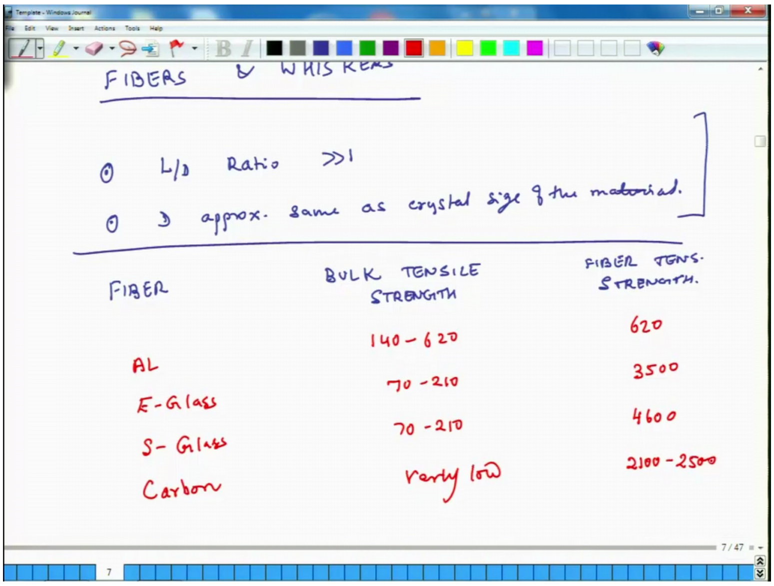

So, with this background, let us look at some of the properties of different fibres. So, we will have I will quickly develop a table. So, you have fibre. And then I will say that what is it bulk tensile strength, bulk tensile strength; and then we have the tensile strength are it fibre level, fibre tensile strength ok.

So, we will just quickly look at some fibres. So, the first one could be fibre made of aluminium and its bulk tensile strength in mpa is anywhere between 140 to 620, but if you test the thing at the fibre level it is pretty close to 620. So, the material is much more consistent. So, then the next one is let us look at glass, and there are different types of glass fibres. So, this is E-glass fibre bulk strength is somewhere between 70 to 210 mpa; but if you look at the fibre strength, it is 3500 mpa ok.

And if you take another glass, let us say S-glass, its bulk strength is again 70 to 210; but if you look at its fibre and you try to break it, it breaks at very high stress level about 4600 mpa or 4.6 gpa. And then we will look at another very popular fibre made from carbon, graphite fibre. And if you take graphite and you try to break it, it will break it almost no load. So, it is very low, because they are lots of defects in between flux. And but if you look at its fibre strength, then it could be anywhere from 2.1 to 2.5 gpa or 2100 to 2500 gpa.

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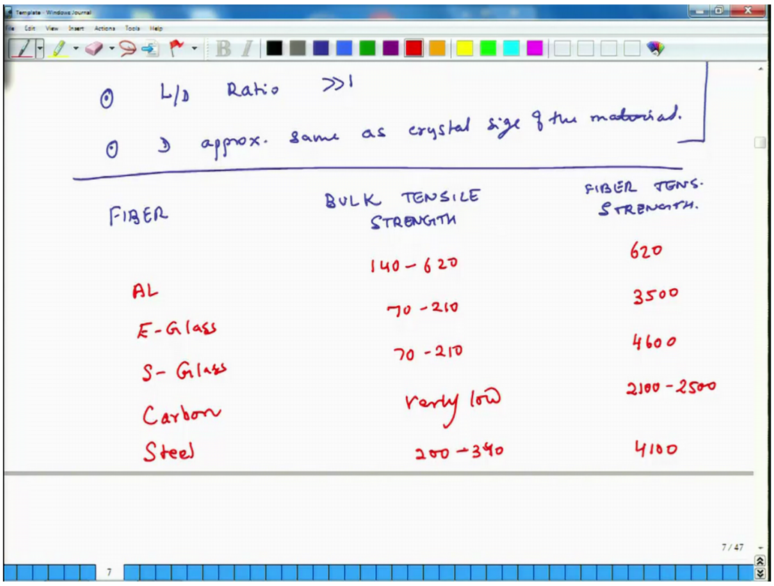

And lastly we will look at steel. And steels breaking strength and bulk form, so this could be anywhere between 200 to 340 mpa; but at the fibre level, it will break something at much elevated values about 4.1 gpa. So, this gives you an idea that if you use fibres, and if you use a lot of fibres, then you can make a product stronger than it would be when you use the same material in its bulk form, because they are stronger. And because of this come a lot of times composites have a very high strength to density ratio that for the same amount of mass you can have much stronger structures.

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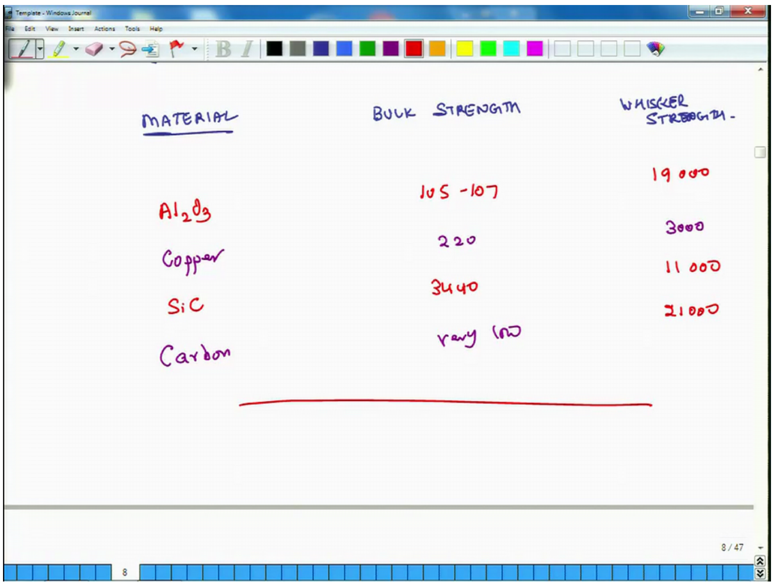

So, the other term which I used was whiskers. And these whiskers are very similar to fibres, but the difference is that they are even thinner, they are even thinner than fibres and they have even higher properties even better properties than fibres. So, let us look at some of the whisker strengths. So, we will have material and then we will look at their bulk strength, and then whiskers strength. So, we will start with alumina. So, you can actually make whisker from alumina; and its bulk strength is about 105 to 107, but its whisker strength is extremely high 19000 mpa ok.

Another would be copper. So, copper is about 220 break setup out 220 mpa, but you look at its whisker it goes up to about 3 gpa, so about 15 times stronger. Silicon carbide silicon carbide it breaks at about 3440 mpa or 3.4 gpa, but at whisker level it fails at 11 gpa. And then we will look at carbon, again a very low, but whisker strength if you compare so the fibre strength was how much 4100 mpa or 4 it was about 2100 mpa, 2100 to 2000 mpa. So, about 2 to 2.5 gpa. And the whiskers strength does not change much, but it is in the same range 2500.

And we will take two more examples, so that you have a good perspective. So, one is E-glass. So, E-glass is 70 to 210; and its strength is at whisker level is about 3500. And then finally, we will talk about titanium, titanium alloy it breaks at about 1040 and its whisker strength is 1900 mpa. I messed up with some numbers, because this graphite is actually very high, it is about 21000 ok. And this data is incorrect. So, these are four sample materials. And they give you some idea as to how whisker strength of different materials can be very high.

So, the point is that using these types of properties at micro level, we exploit their superior properties, their higher strength, higher modulus and things like that. And using that we are able to engineer tailor made materials which meet our requirement. So, this is the overall view.

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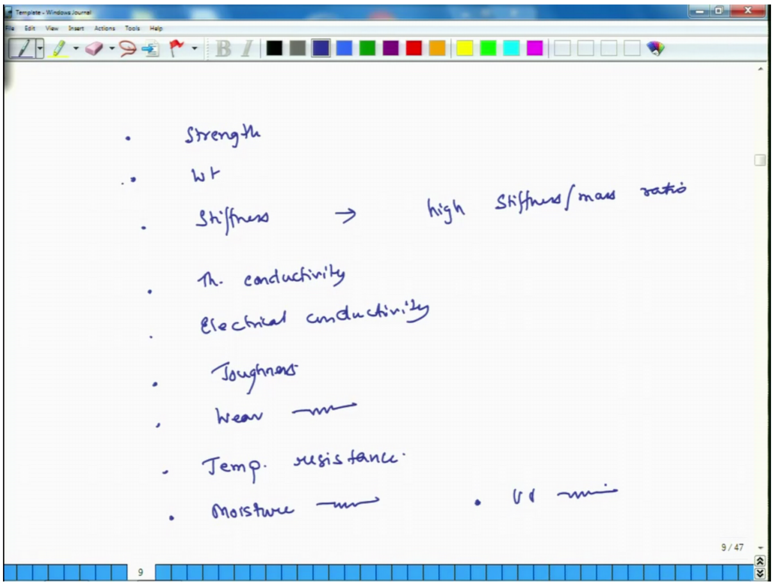

And what are the different types of advantages we may get out of composite materials. So, let very let us very quickly review. So, I can engineer a composite material to provide me benefits. And what could be those benefits? They could be so it all depends on how I engineer the material. So, it would be strength. Weight I can have very light composites so weight. Stiffness; and in this context specifically I want to say that less stiffness to mass ratio. And again in context of strength also I can say that less strength to high stay high stiffness to mass ratio and high strength to mass ratio. So, I can engineer that.

Then I can engineer materials to improve their thermal conductivity, electrical conductivity. Toughness, a very good example of a very tough material is Kevlar and that is why they use it for a lot of bullet proof application bullet proof jackets and things like that. Wear resistance ok, so you can have toughness, you can wear resistance, temperature resistance ok, moisture resistance, ultra violet - UV resistance ultra violet resistance and so on and so forth.

So, again a single material may not give you all these properties. But if you know exactly what your functional requirements are, then you can engineer a particular composite material to particular goal. So, this completes our second lecture for the week. And tomorrow we will start discussing the mechanical behaviour of different types of composite materials in not necessarily in a mathematical sense, but initially we will start discussing in a qualitative sense, and then slowly we will move into the mathematics of different types of relations which govern behaviour of composite materials. So, with that we close for today. And I look forward to seeing you tomorrow.

Thank you.