Technical Textiles
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Lecture - 9
Textile Reinforced Composites (Contd.,)

Hello everyone. In the last class what we have discussed how to manufacture thermally bonded roving using flax and polypropylene, where polypropylenes are aligned towards the axis of the roving and there is no twist imparted in the strand and today I will discuss the manufacturing of composite out of this Flax-PP thermally bonded roving, the 2 approaches will be discussed here.

As I have already mentioned in last class that one will be unidirectional composite, another we will use that thermally bonded roving for converting to woven fabric. So, the composites will be manufactured using that thermally bonded rovings. So as already been mentioned that the flax being hydrophilic in nature.

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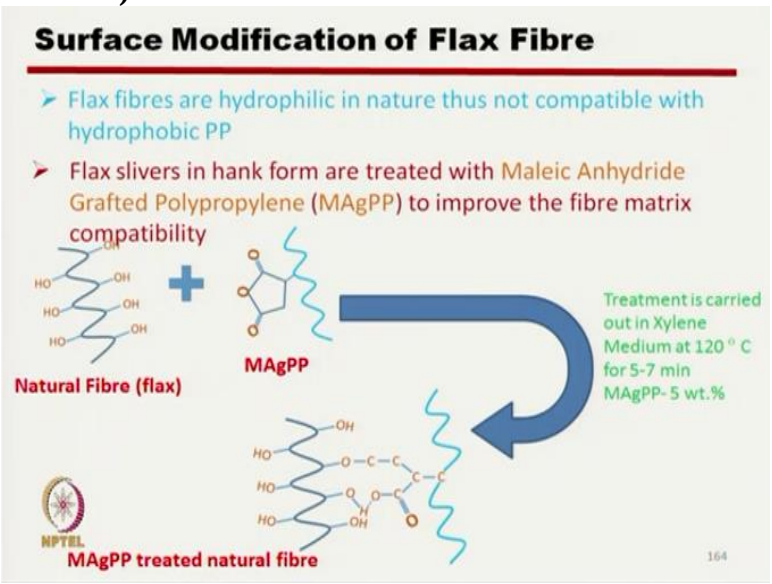

So, it is not compatible with the hydrophobic polypropylene fibre, so polypropylene has matrix. So what has been done? That surface modification of flax was done using Maleic anhydride grafted polypropylene, which is known as MAgPP. So, easily using this MAgPP treatment we can use this grafted or surface modified polypropylene sorry surface modified flax fibre as the reinforcing material when polypropylene is used as matrix, ok this is the surface treatment.

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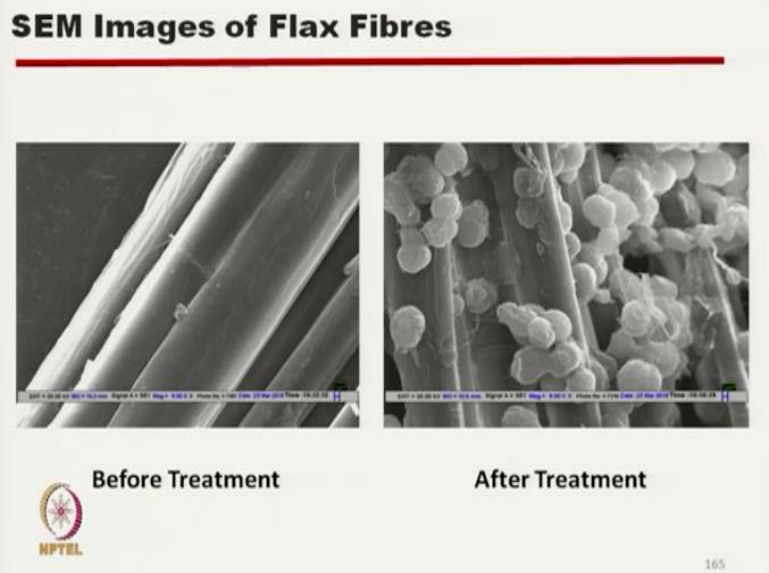

If we see the before surface treatment of flax fibre, there is no such chemical depletion and these are the MAgPP. In fact, this MAgPP helps in proper binding with the polypropylene matrix and we will see the characteristics without treatment and with treatment. So, in with treatment we have seen the significant improvement in properties.

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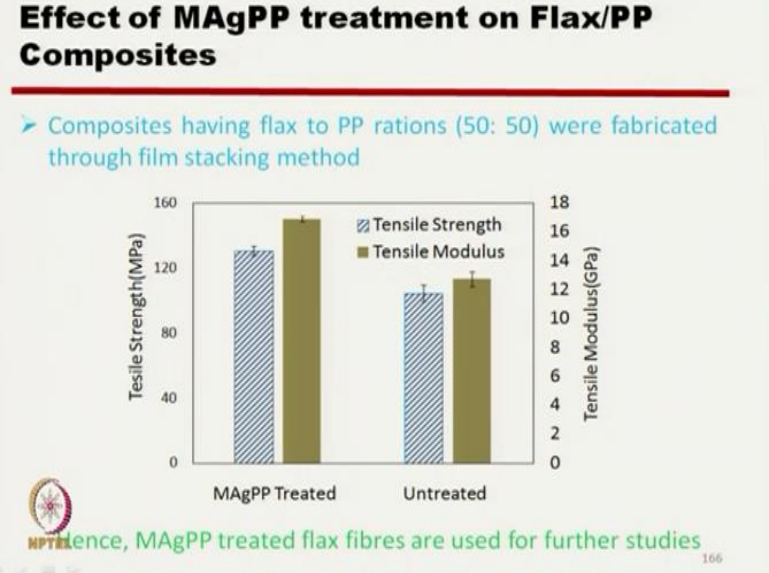

So, if you see here we have used 50:50 polypropylene and flax ratio and we have fabricated the composite using film stacking technique and this 50:50 ratio is at the composite stage. If we see in the thermally bonded roving stage, what we have used it is a 60:40, 60% flax and 40% polypropylene and once we add extra film, polypropylene film in between the series of rovings so, polypropylene percent has increased so, it up ultimately it has become 50:50.

So, if we see the picture here that this graph here that is MAgPP treated composite and untreated composite that take both tensile strength and tensile modulus in case of treated

composite is higher than untreated. So, what we have done for further studies we have used the treated flax fibre composites so, MAgPP treated flax fibres are used for our further study.

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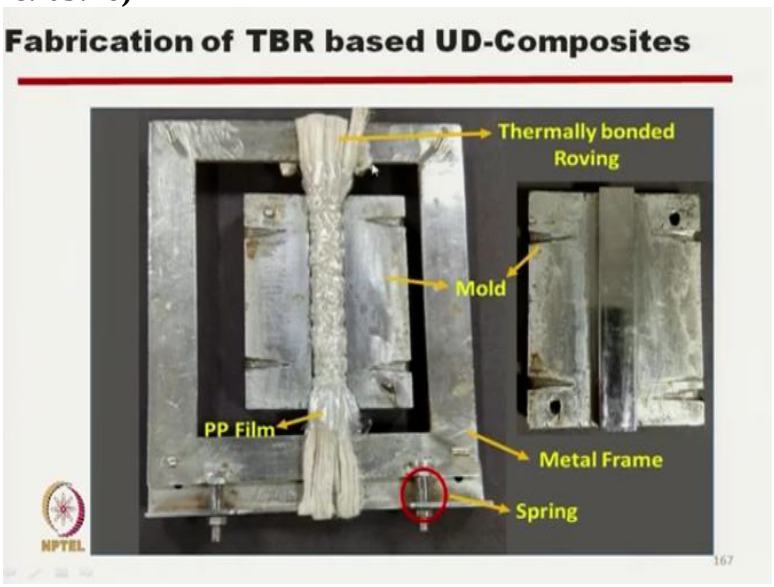

This is the photograph of the composite making process, which is a unidirectional composite, these are thermally bonded roving this parallel laid, TBR and these are the PP films this is one of the films. So, layer by layer it has been placed. So, this in the mold and this is a metal frame and by compression molding, the composite was manufactured.

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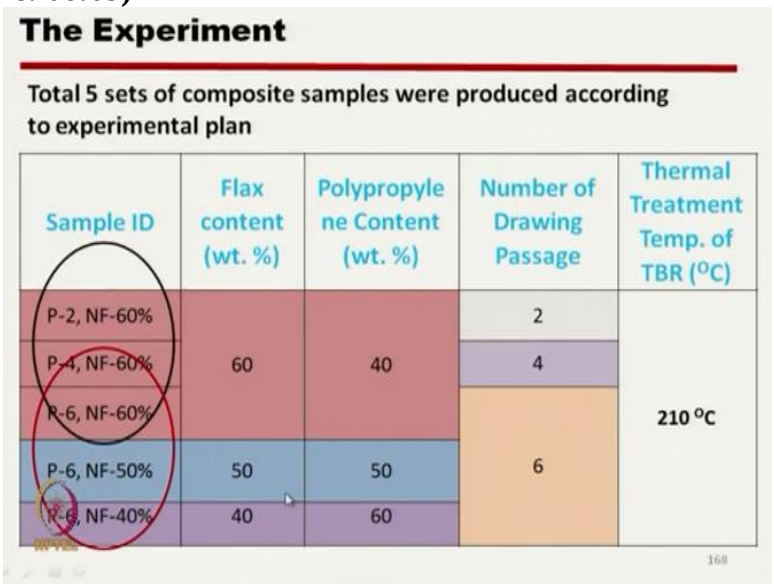

Here we have taken 3 different variables again, this is number of passages, passage 2, 4 and 6 passages, where natural fibre percent in the unidirectional composite was kept 60%. Another variable was that the natural fibre component was 40, 50 and 60. So, this is polypropylene content, flax content and this is at the total composite stage will be ultimately 50:50, composite to here we have prepared it is up to 50:50.

But these are the, in the TBR stage, thermally bonded roving stage number of passages and the treatment temperature for all the composites we have used here it is 210. So thermally bonded roving which has been produced at 210 were used in this composite making process.

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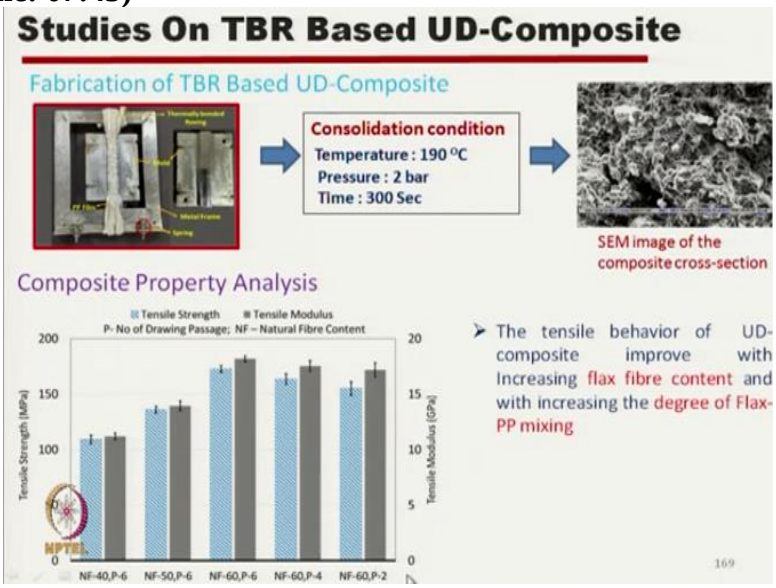

So after consolidation, if we see this is the scanning electron microscope image where the polypropylene and flax it is clear that they are mixed almost uniformly. If we see the property here with the blue bars, this is tensile strength and the grey color, it is the tensile modulus, NF means natural fibre component 40%, 50% and 60% and P means number of drawing passages first 3 combinations they are drawing passages constant.

Here passage is 4, here passage is 2 now, if you see once we increase the natural fibre component we see the tensile strength of the composite increases, which we have already seen for thermally bonded roving stage and also, once we increase the number of passages 2, 4, 6 we observed that both tensile strength and tensile modulus increase. The tensile behavior of unidirectional composite improves with the increase in flax fibre content and with the increase in degree of PP mixing, which is indirectly shown by number of passages.

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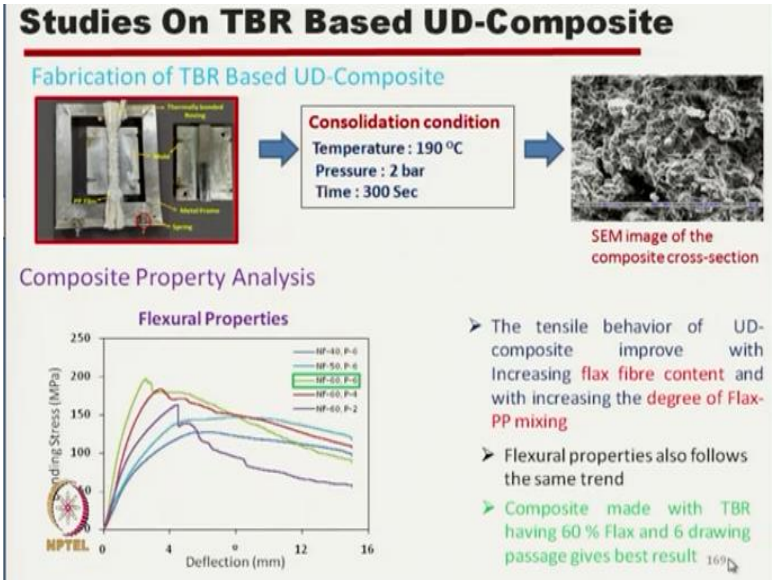

The flexural property also shows the similar trend, that is with the increase in the natural fibre component and with the increase in number of passages the flexural strength increases, the bending strength, bending stress it is a, it increases and if we see the green this is natural fibre component 60 and passage 6, this one, it is giving highest bending stress. So, composite made with thermally bonded roving having 60% flax and 6 drawing passages shows best results.

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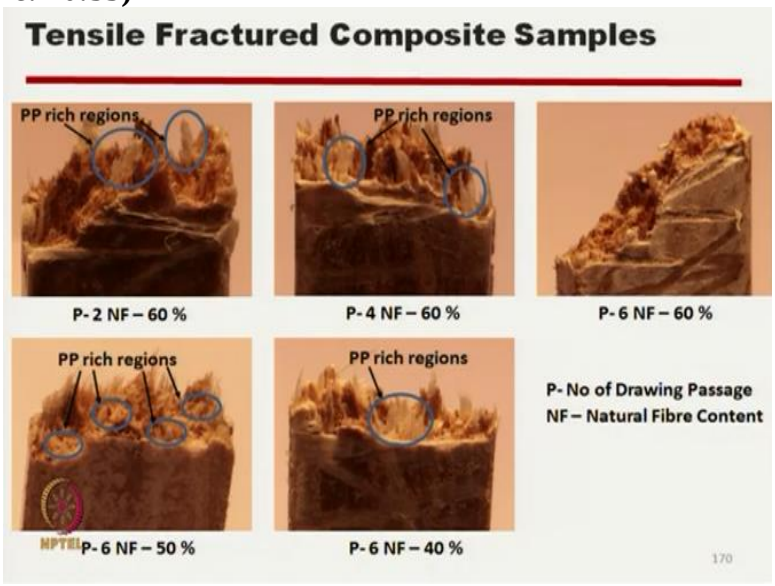

So these are the pictures of fractured composite samples. Here we can see for say 60% natural fibre component after fracture, we can see here this is polypropylene rich region and this is here we can see it is a polypropylene rich region where it is a white patches we can see. Even at the 4 drawing passages, we can still observe the polypropylene rich zones but when we increase the, this passages to 6, these are uniform. So, basically, if we have to produce the thermally bonded roving using natural fibre and say thermoplastic matrix fibre so, we have to use more number of drawing phases for better blending.

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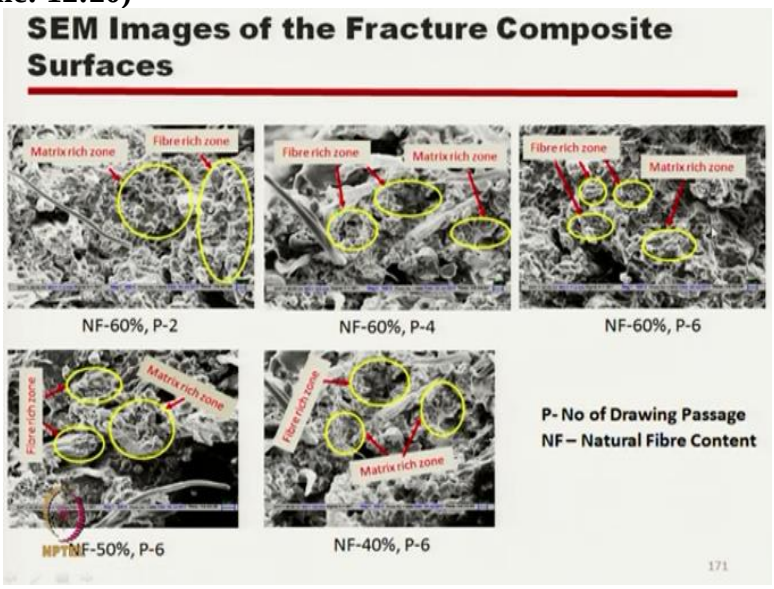

So, this is the same image it is showing similar effect to polypropylene rich and matrix rich components are also there, but, if we see these are the polypropylene and matrix zones. Here interestingly we can see here at 2 passages, the zones for matrix zone and fibre rich zone, matrix rich zones and fibre rich zones are larger in size, but as we go on increasing the number of passes this matrix zone and fibre rich zones are becoming smaller and smaller that is obvious because of the proper blending.

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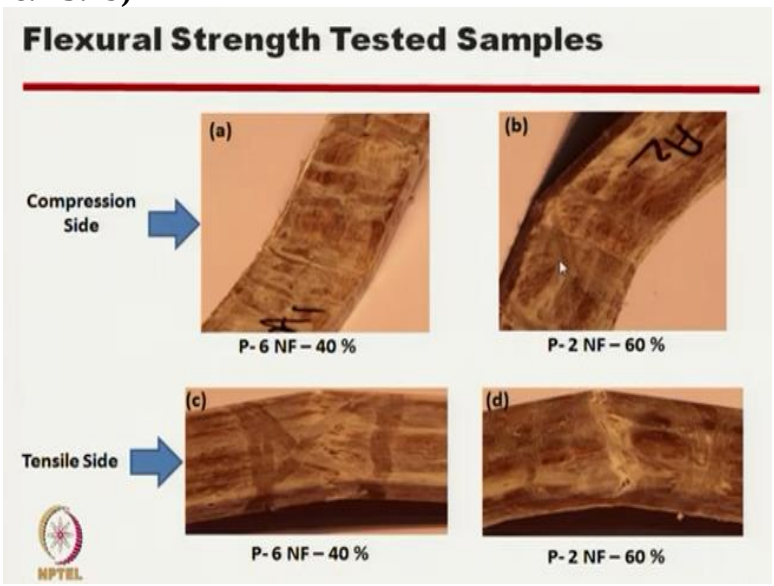

Now, if we see this picture, this shows that after flexural strength testing what is happening here, this is compression side and this one is the tensile side, in compression side with number of passages of say 6 as they are evenly distributed this matrix and reinforcing fibres are evenly distributed there is no delamination or less delamination. But at lower level of mixing we can see they are getting easily delaminated.

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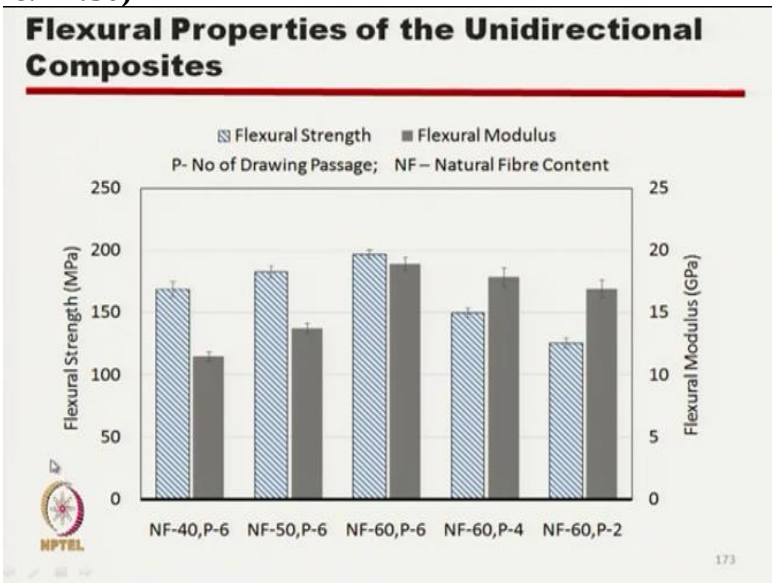

So, this trend we have already seen with the increasing number of passages from 2, 4, 6, the flexural strength and flexural modulus increases and also with the number of proportion of natural fibre the trend is increasing trend of flexural strength and the flexural modulus.

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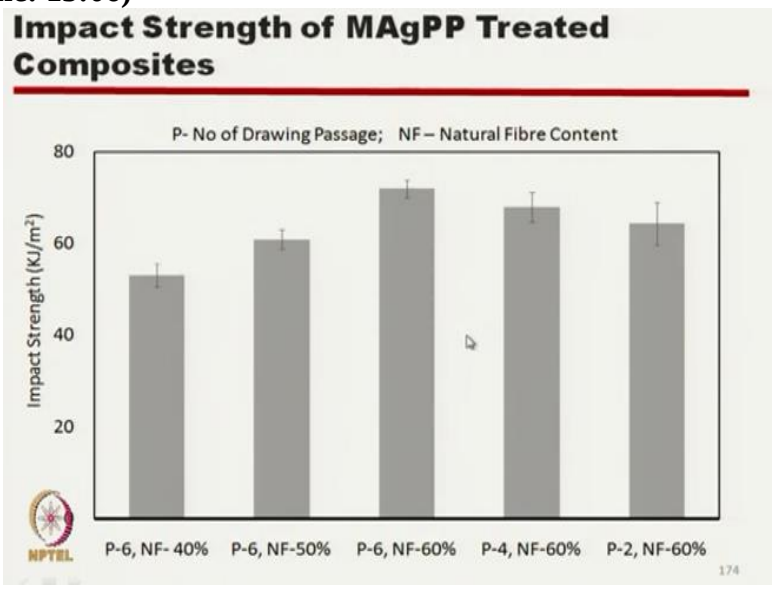

Now, impact strength of MAgPP treated composite if we see it we are getting the similar trend that means, the impact strength increases with the number of passages from 2, 4 and 6 it increases and also the number of same number of passages of 6 if we increase the proportion of natural fibre content 40, 50, 60 the impact strength increases.

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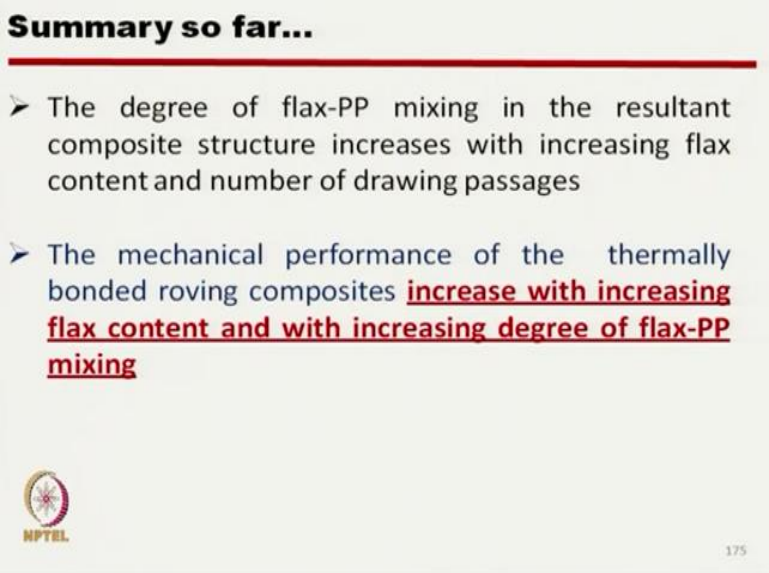

So, the summary which we are we can conclude here the degree of flax and polypropylene mixing in the resultant composite structure increases with the increasing flax content and number of drawing passages. And also the mechanical properties of thermally bonded roving, the composite made of thermally bonded roving increases with the increase in flax content that is reinforcing fibre content and with the increase in the degree of mixing that is number of passages.

Next study was that is that woven fabric we have developed, the plain woven fabric and we have compared with the and after making woven fabric, we have developed composites by film stacking technique and the composite made of film stacking technique that the woven fabric the characteristics of this composite was compared with the unidirectional composite as already been just discussed and also with for reference we have taken the glass fibre reinforced composite.

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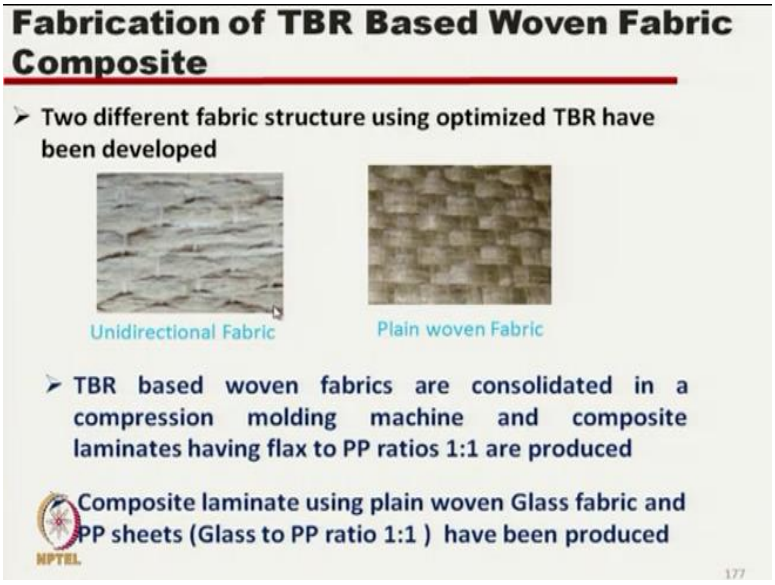

What we have done we have developed unidirectional fabric and plain fabric. So, the difference here is that in unidirectional fabric we have used in the warp the polypropylene filament with the very low ends per inch, we can use this thermally bonded roving for warp also now, let us see suppose this is

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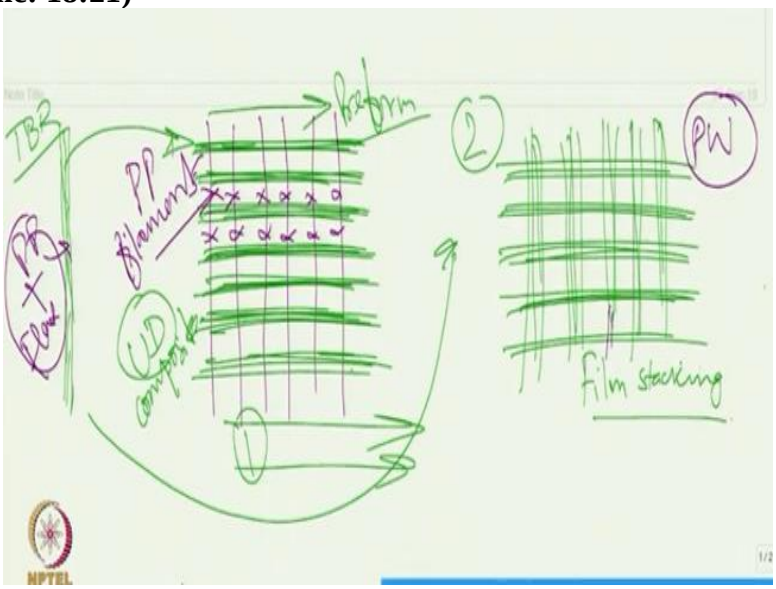

TBR thermally bonded roving what we have done this the warp, warp PP filaments. Here, what we have used this TBR already made as weft. Effectively, so this is a fabric, this is, say preform and this as it is PP warp is PP. So, this fabric once we produce composite out of this fabric by film stacking technique this polypropylene will be mixed with the matrix component effectively.

We will see this direction weft direction, this TBR will have the fibre reinforcing exists fibre aligned to the, this direction only aligned to so that is why we call it as unidirectional

composite. Another approach what we have used, we have used this TBR, this is approach 1, in approach in 2 what we have done this TBR was used both for warp and weft although in TBR we know thermally bonded roving here both PP plus flax are present here.

Now, this woven fabric, plain woven fabric was used to manufacture the composite by again film stacking technique. So, these 2 different structures were developed this is unidirectional fabric and this is plain woven fabric. TBR based woven fabrics are consolidated in a compression molding machine and composite laminate having flax and PP ratio of 50:50 were produced so, using the PP film.

So, final product final composite where the polypropylene and flax proportion was 1:1, composite laminate using plain woven glass fabric and polypropylene sheet also produced keeping the ratio of glass fibre and polypropylene one is to one again. So, we have used glass fibre as reinforcing, this is just for comparison. Now, this is the, you can see here this is a unidirectional rovings are unidirectional here rovings are used for both warp and weft.

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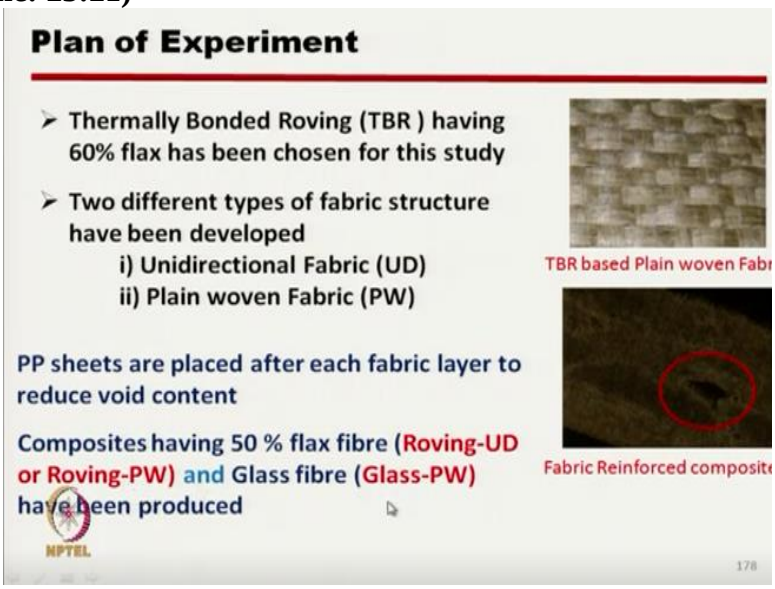

So, the thermally bonded roving with 60% flax were used ultimately in the composite it has become 50:50. So, 2 different types of fabrics are used unidirectional fabric and plain woven fabric it is called UD we are calling it as UD and this is PW and this is woven fabric and once the composite is manufactured by film stacking technique so, this is the surface. We have observed for few fabrics to some specific zones the void or improper melting was there.

Due to some composite making problem and we have eliminated all those samples. So, PP sheets are placed after each fabric layer to reduce the void content. So, we use this we found that if we do not use PP sheets after each layer so void content increases. So, we have used PP sheets after each layer so, composite ultimately having 50% flax so, roving UD or roving plain woven and also for glass plain woven fabric they are produced.

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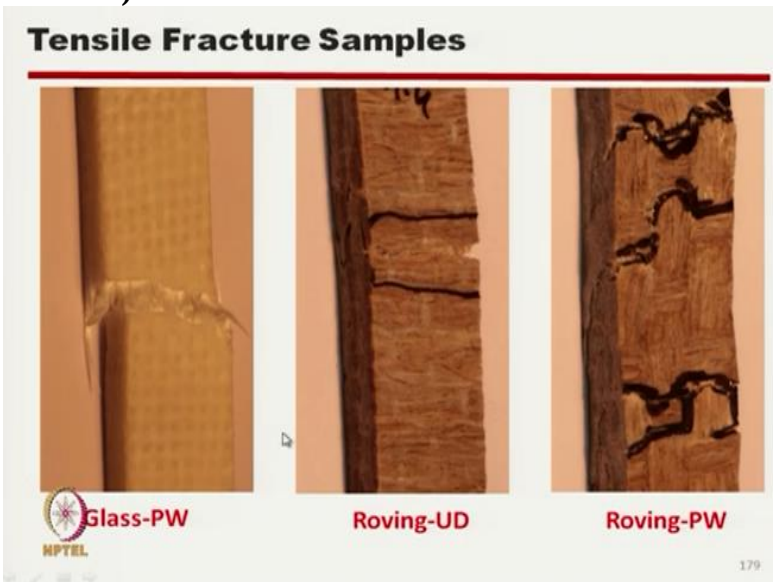

This is showing type of fractures roving plain woven composite the plain woven composite shows the multiple fracture and also unidirectional roving we have seen there are more than one fracture point but in case of glass woven composite the fracture takes place in it is weakest point at a single unit point fracture has been observed.

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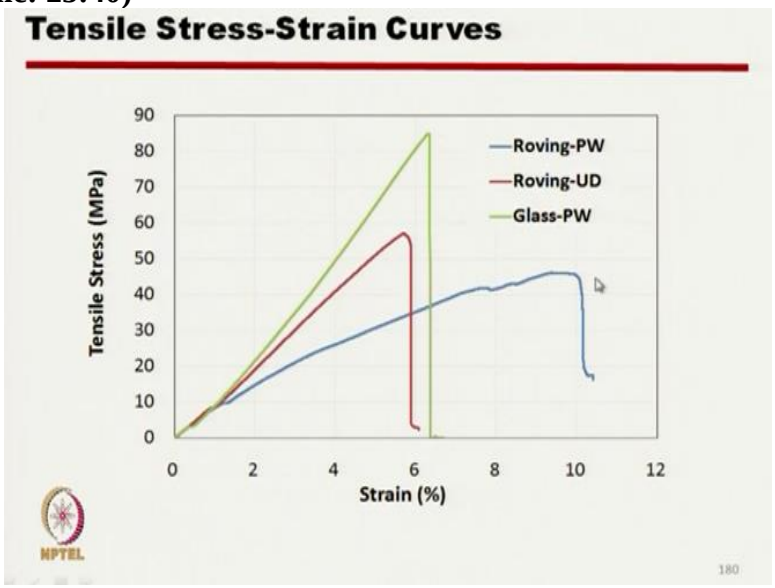

But if you see the tensile strength, tensile strength of glass composite it was much higher than the flax based composite. This is actually ultimately strain and stress here so, glass is having

much higher than the roving, plane woven and roving unidirectional. So, unidirectional is showing higher than the plain woven fabric. The obvious reason because unidirectional roving composite the fibres are aligned straight towards the stress direction, whereas in plane woven roving this is a plane woven roving the rovings are little bit crimped when we placed inside the composite that is why the strain is much higher.

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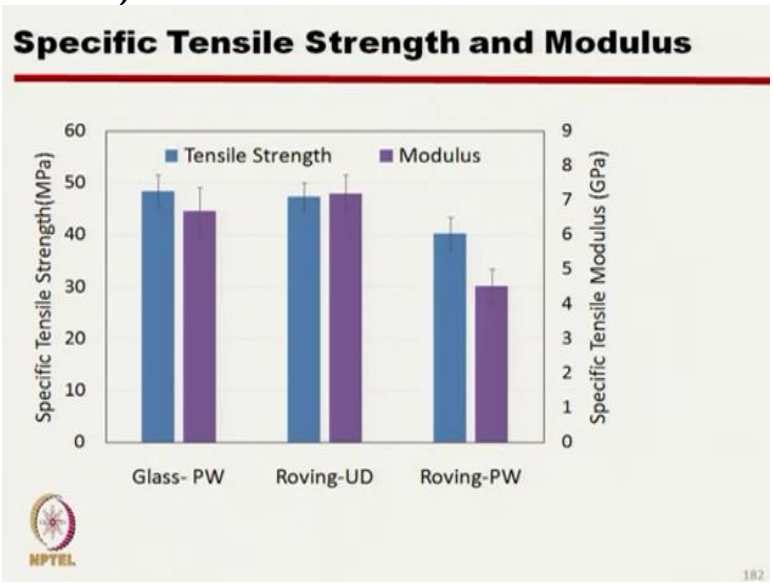

Similarly, if we compare the tensile strength and tensile modulus with the glass plain woven fabric, these are much lower both tensile strength and tensile modulus are lower than the glass plain woven fabric. But once we compare the specific tensile modulus so, this is the modulus, this is tensile strength, once we compare the specific tensile modulus these are specific tensile strength both specific tensile strength and specific tensile modulus.

The roving unidirectional roving or roving UD is comparable or better than the glass plane woven fabric. That means, if we take the mass into consideration, so for unit mass the strength of flax PP composite, particularly unidirectional composite, it is showing better result than or equivalent result as compared to the glass plain woven composite. But plain woven roving still is showing lower modulus and strength. That is mainly due to the crimp present in the fabric which is giving higher strain and lower strength.

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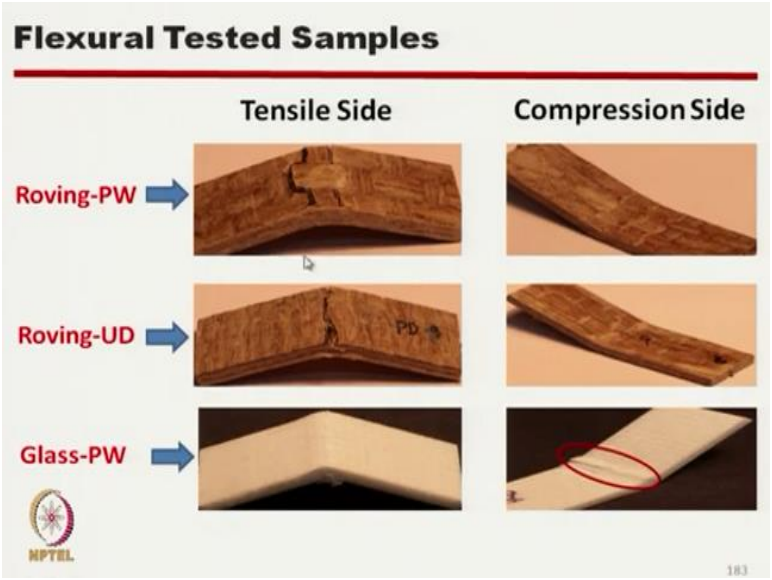

Now, this is a roving plain woven fabric where we have observed, we have already discussed multiple places there are damages, this is unidirectional roving and this is glass PP plain woven. Interestingly you can see for glass PP plain woven composite at the compressional side when we bend due to during a flexural testing delamination is taking place. But, this delamination is absent in case of flax polypropylene composite, which is very good sign as far as the flexural characteristics is concerned.

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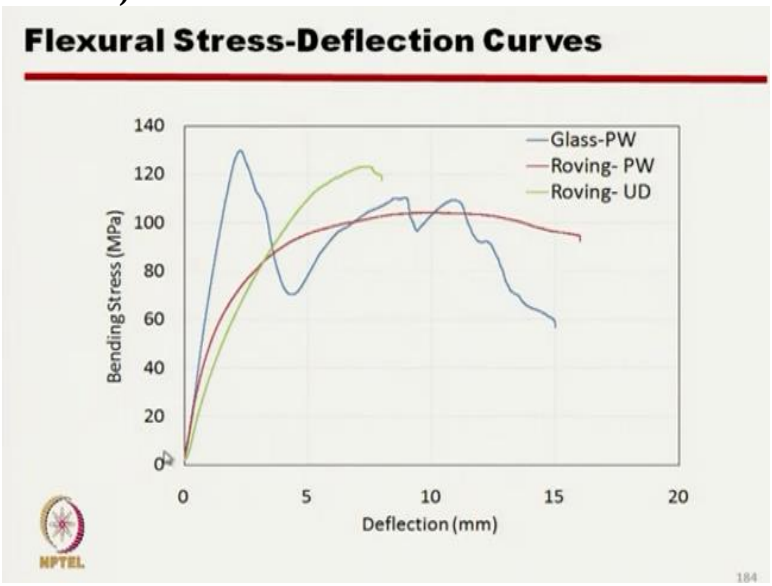

Here we can see during the flexural stress and deflection curve in this curve, you can see here during flexural testing, although the flexural strength is high, but due to delamination it is not able to, the composite is not able to, sustain that load suddenly the stress drops. But, on the other end the flax polypropylene roving based composite, although their ultimate bending strain is low, lower than the glass but still they maintain certain stress level.

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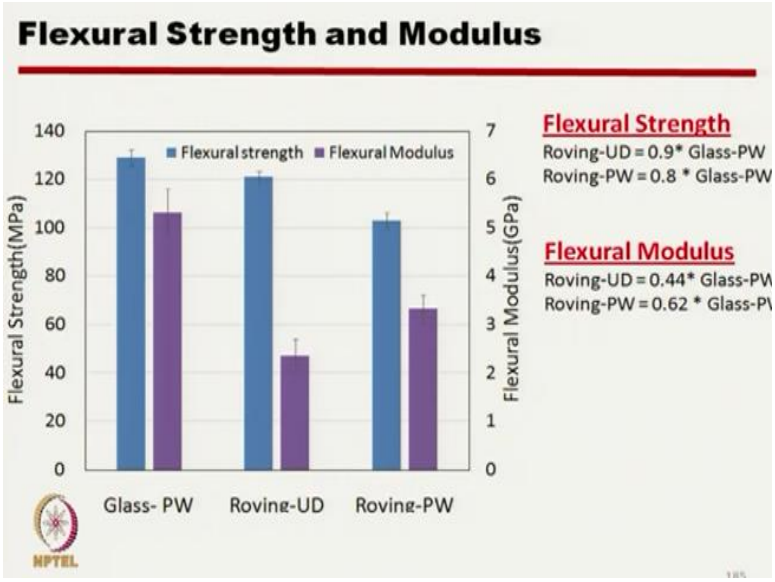

So, if we know flexural strength and this is the flexural strength of roving, plane woven roving. So, these are lower than the glass, but as we have already seen the specific stress, if we see it will be at comparable with the glass.

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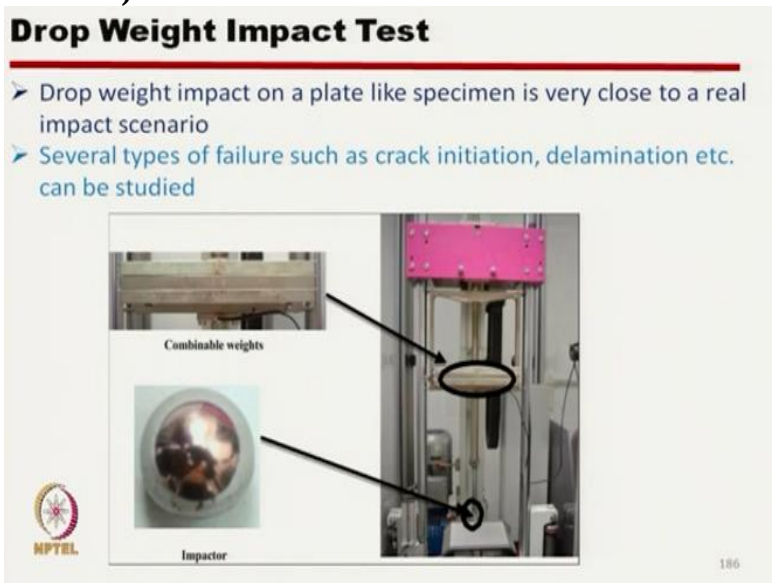

As far as impact strength is concerned we have used the drop weight impact tester and here we have to use a plate like specimen, this is the impactor.

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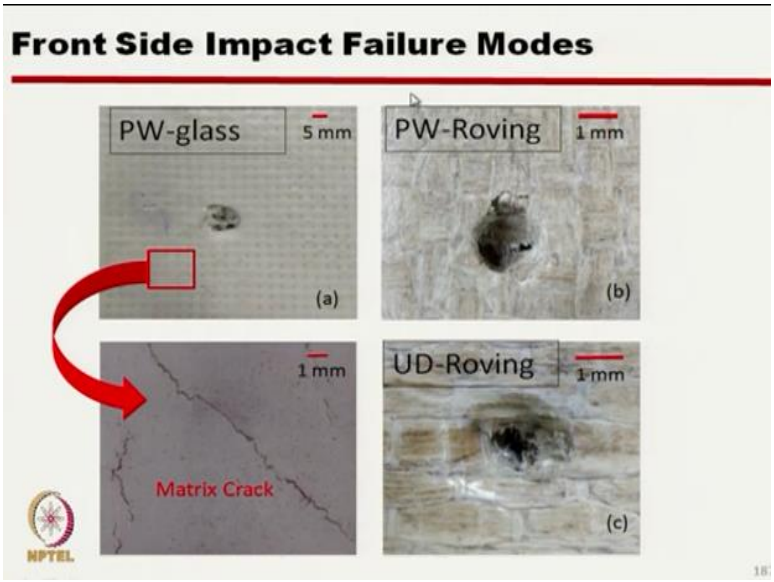

And here if we see the glass plane woven in glass fabric there is a crack formation. This crack formation is due to delamination mainly and the diameter of the hole created is much lower than the plain woven roving or unidirectional roving composite.

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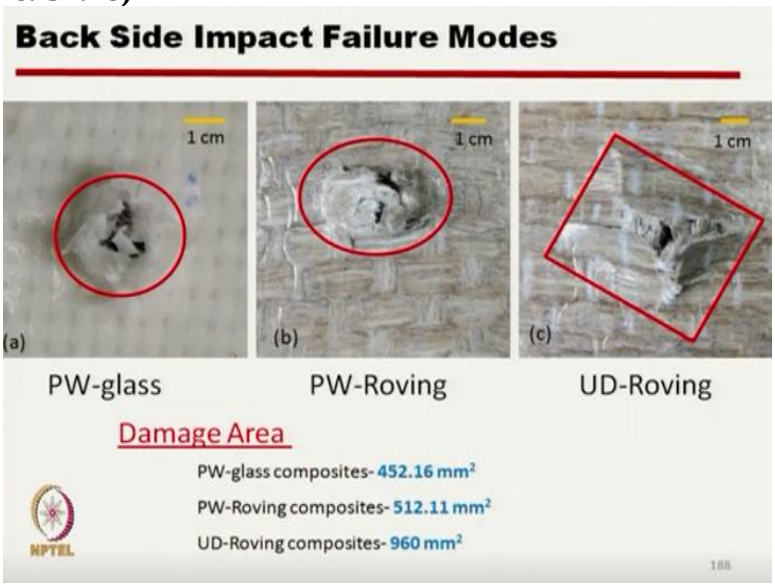

So the damaged area for glass is has been observed 400 around 450 square millimeter plain woven roving it is 512 and unidirectional roving it is very high here, it is a 960 square millimeter.

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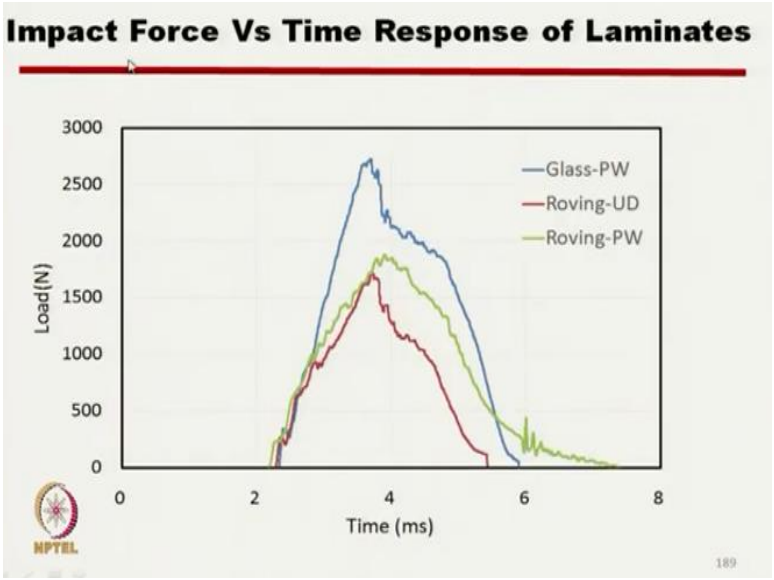

Impact load time response the impact load is higher here and roving, plain woven roving, it is followed by plain woven roving and unidirectional roving is actually behaving in the inferior manner, as we have seen in the earlier picture, unidirectional roving, it is giving higher damage area.

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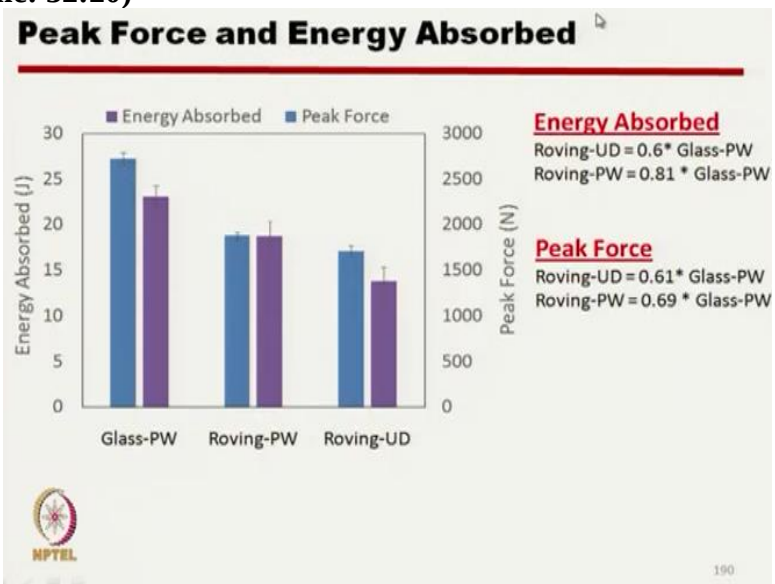

So, peak force and energy absorption, energy absorption in glass is much higher than the unidirectional roving composite and it is also higher than the plane woven composite. So, we will end this session now here, in next class, we will start with the characterization of fibre reinforced composite materials, till then thank you.