Advanced Topics in the Science and Technology of Concrete
Uni-axial tensile test of textile reinforced concrete (TRC) panel

Hi all, my name is Sachin Paul I am doctoral research scholar working in building technology and construction management department of IIT Madras, my area of research is on textile reinforced concrete, I will be explaining what is textile reinforced concrete and how a uni-axial tensile test is done for textile reinforced concrete and what are the factors that we need to consider while we are doing a uni-axial tensile test.

This test can be also done for other materials with fine grain aggregates basically mortars of fine grain high strength concrete can be also tested, there is limitation for testing on larger aggregate concrete but this is basically as per rilem standards of 2016 rilem test methods of 2016 for uni-axial test of textile reinforced concrete, okay.

Now I will explain to you what a textile reinforced concrete is, so a textile reinforced concrete is a concept where we are combining a normal concrete with textiles as reinforcement. Now what is the advantage of this is that the textiles that we use are either carbon, polymeric or glass fibre textiles, these does not corrode in an aggressive environments so it is a corrosion free element.

So we can have a very thin element structural, both structural and non-structural elements with high capacity and it can be used for very thin application exterior applications and he has very high durability since the corrosion is not happening this material, okay.

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So here with me I have a example of how what a textile is this is glass fibre textiles these are e glasses coated e glass textiles. So these textiles comes in a role of 50 meters, usually have a width of 1 meter. So we incorporate this in fine grain concrete, why fine grain concrete is because when you have textiles of small measures you need aggregates to be very small such that you could easily penetrate to the small gaps of the textiles. So that is why we are basically using a fine grain concrete.

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So this is a strip of textile that we have cut out from this roll this is what we use for reinforcement for uni-axial tensile test specimens, this final specimen that we fabricate after will be looking something like this, the dimension of the specimen will be 60 mm width, 10 mm thickness and a length of 500 mm, this is actually a four layered textile, so we have four layers of textile inside it with a spacing of 1.5 mm each. What we are trying to do is do uni-axial tensile test with respect to this.

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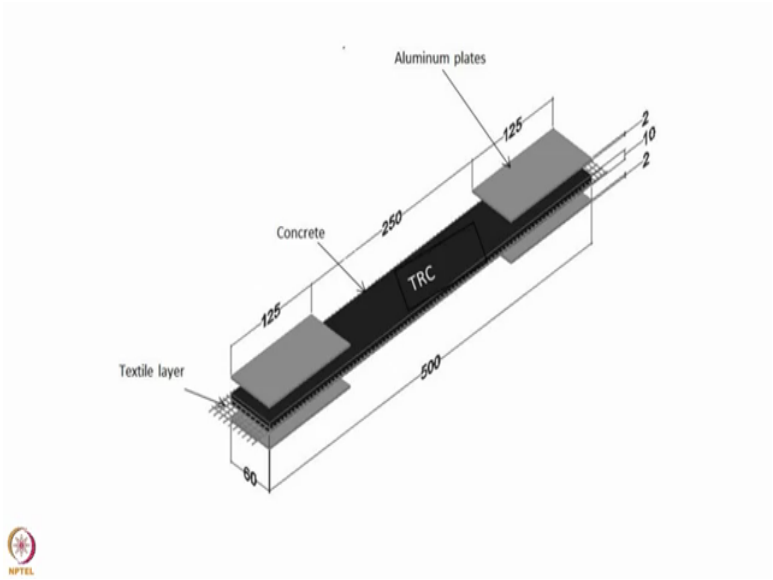

The maximum size of aggregates that we use in this is around 0.6 mm, so it is a very fine grain concrete. So the problem a uni-axial tensile test is the gripping is the primary problem how to grip the specimens. So what we use is a aluminium plates that is attached to the end such that the crushing failure does not happen during the gripping process.

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These are specimens that is attached with aluminium plates so we cut out rectangular aluminium plates on the gripping area and we ebbed them or we fix them with epoxy regions and we let them cure for 1 day, then we are doing the test after that. So this prevents the crushing failure of the support due to the pressure that builds up during the testing process or gripping process.

Now gauge length for the uni-axial tensile test is basically a 200 mm gauge length as per rilem standards. So we will be using a combination of two axial extensometer one is axial extensometer, another one is a video extensometer and with combination of this we will be trying to find the strength variation or the displacement in this material with respect to the load acting on the element.

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This is a 100 mm axial extensometer so what we are trying to do this is a contact type axial extensometer so we will be attaching the axial extensometer to a 100 mm gauge length on the specimen and this is a dual axial extensometer that means it has two axial extensometers and what we get is average of both the displacement from the two sides, okay. So it (gets) gives you an average displacement that is happening in the two phases of the specimen.

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So here is a setup for uni-axial tensile test for TRC, we use two systems for taking out the displacement or the strain of the element one is the axial extensometer, so this is an axial extensometer of 100 mm gauge length as I have said this is a dual axial extensometer where you have two setups for the axial extensometer and you get an average of the two displacement at the two phases.

We also have a video extensometer a video extensometer is a non-contact type extensometer, so this is a video extensometer, the video extensometer has two sets of camera, the video extensometer detects the contrast between white and dark spacers in any image and converts that into pixel and whatever displacement that is happening with respect to those pixels it records as a strain or displacement, okay.

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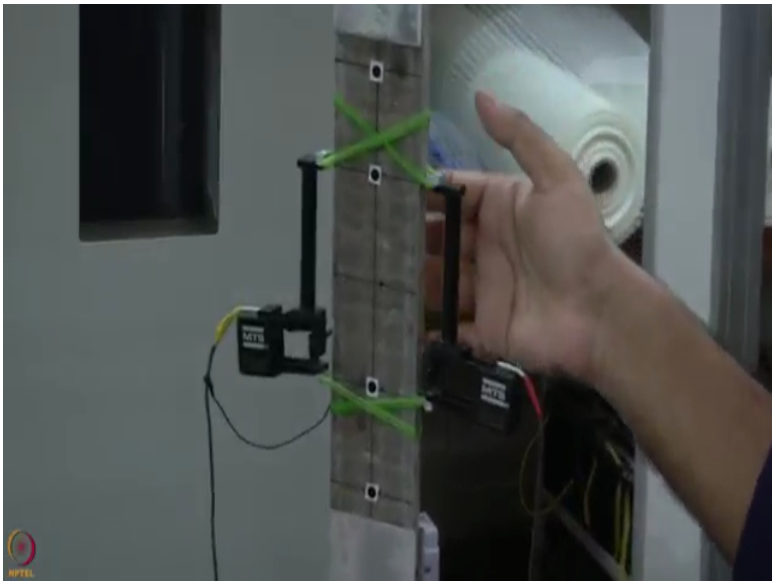

So basically I have marked 4 points or 4 positions in the gauge length of the specimen, the first one is 100 mm gauge length which is equal to the axial extensometer, why? This is to detect whether the video extensometer ratings are as same as that of what we observe in axial extensometer, the second one is a gauge length of 200 mm where (the) that is as per the standards of rilem for testing of textile reinforced concrete.

So the video extensometer (detects) can detect between any given 4 points or 5 point or any n number of points given in the framework of the video. So once we have tested for example if we need to find the gauge length or displacement between the gauge length of 200 mm you can test between the gauge length of 200 mm and then after testing you can actually go back to the video and then find the difference or the displacement between any other gauge lengths provided in the frame of the video.

So that is one of the advantage with a non-contact type extensometer, the other advantage is that this material can crack anywhere in the specimen. So for a contact type extensometer when you crack when you have crack near to the extensometer it causes distortion in the ratings, this can be avoided in cases of video extensometer, also for a material like textile reinforced concrete you will have multiple cracking that is happening in the gauge length and that can be very well captured by the video extensometer.

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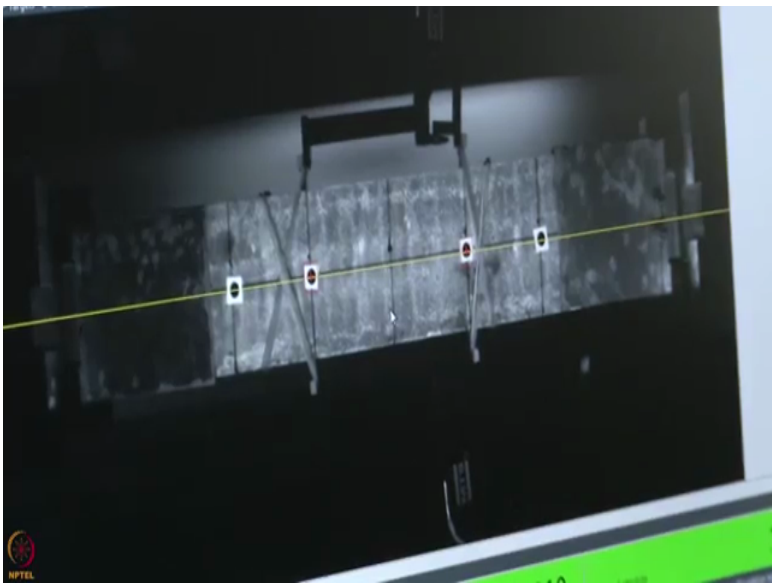

So we are trying to see the interface of the axial extensometer and civic testing machine and we will see how the video is captured and how it is dictated and how the strain measurement is taken out by the video capture, okay. So in the screen what we can see here is 4 points

representing the 4 dots we have in the specimens, the first two dots is a gauge length of 100 mm and the second two sets of dots is the gauge length of 200 mm, the red lines indicates the marking points in the specimen by the video extensometer, what video extensometer measures is the contrast between the white and the dark so you can select the sound of interest and that sound of interest will be marked as the point of reference for the displacement for the video.

Right now I have selected two points of 100 mm gauge length, now after testing if I need to find the gauge length or displacement in a gauge length of 200 mm I can shift to the 200 mm gauge length and do the test again without repeating the test just by rerunning the software just by rerunning the video. So that is one of the major advantages of (axial extensometer) video extensometer where you can do n number of repeated iterations with different gauge lengths with a single test.

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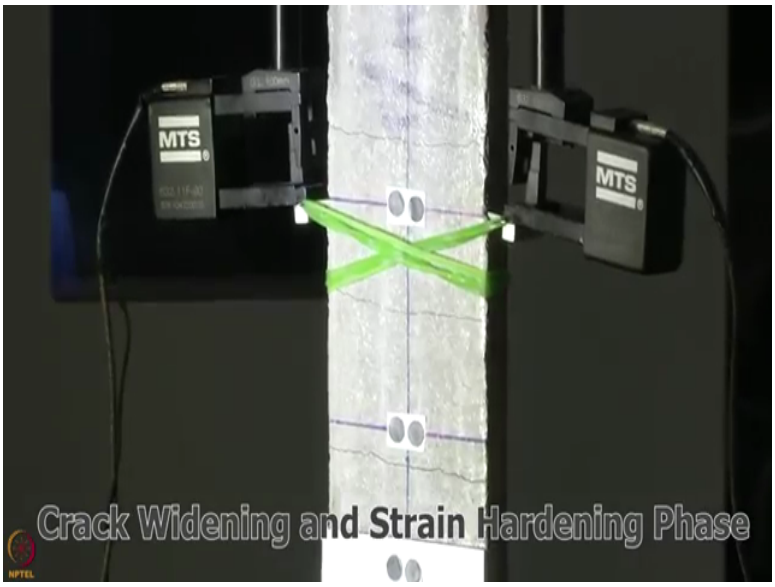

So we will start the experiment you can see the force and the displacement in the you can see multiple cracking forming in the gauge length of the specimen. Now this is where the influence or the advantage where non-contact type video extensometer comes into play, since the cracks can form anywhere, you can also form in the position of an LVDT or a strain gauge. So a non-contact extensometer helps us to take data out even if you have a mechanism like a multiple cracking.

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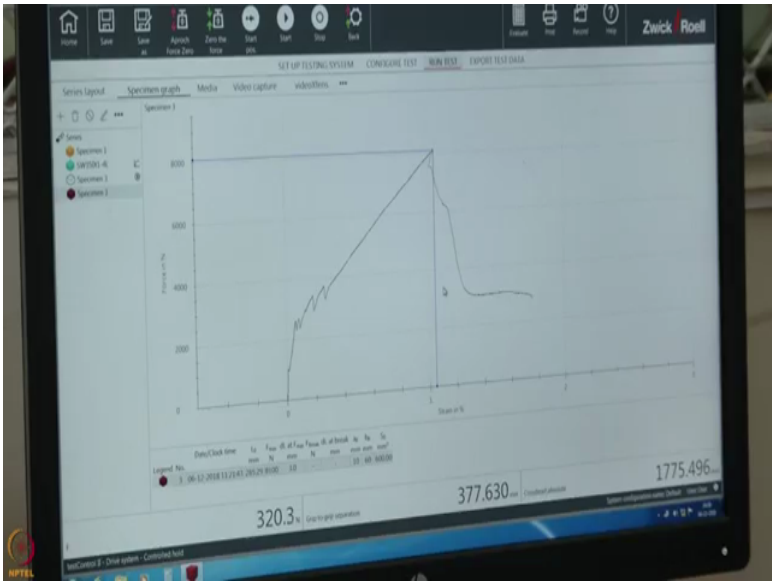

So we have completed the test now and we will look at the stress strain plot of the TRC element and see what are different characteristics that is involved in a TRC element subjected to tensile stress. So this is a basic plot of force versus strain percentage strain we can see two different slopes for the graph, first slope is representative of the matrix properties and the first slope is ended by the first crack formation in the specimen.

So the initial portion of the curve in a textile reinforced concrete test or when textile reinforced concrete is subjected to a tensile stress is represented by the properties of the matrix itself. Once it starts cracking, it forms multiple cracking and it stabilizes at some stages, the stabilization process says that further crack formation is not possible in the specimen.

Once the crack has stabilized then the strain hardening happens in the specimen, this slope of the strain hardening zone is the representative of the property of the textile. So it basically depends upon the property of the textile and the volume fraction of textile that is in the specimen.

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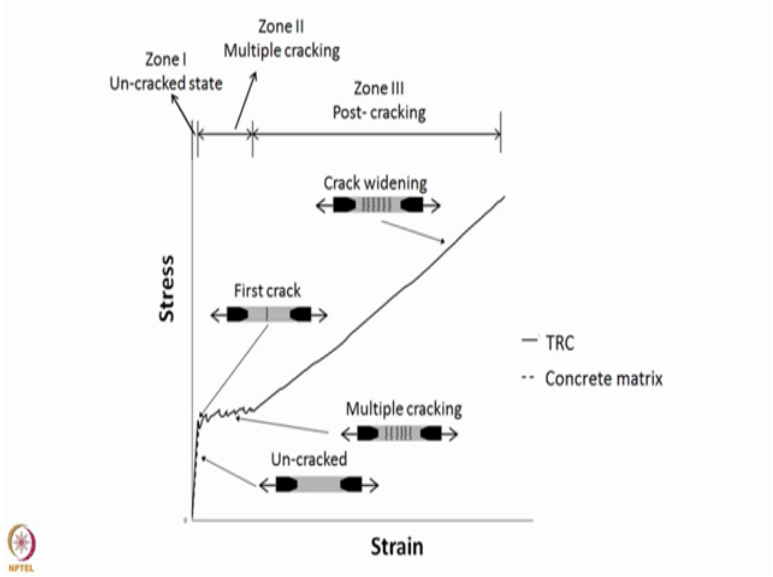

The graph can be basically divided into two segments, the first segment till first crack of the specimen is dominated by the properties of matrix the stiffness is directly proportional to the stiffness of the matrix itself and the second portion is the strain hardening area or the strain hardening zone where the properties of the textile is predominant. Once the multiple cracking has happened then all the tensile stress is taken by the textile.

So we have discussed the specimen preparation procedures, how to mount the specimen, the gripping procedure, how the end plates are fixed, how we use a video extensometer and axial extensometer to take out the displacement in the specimen and also the stress strain response of TRC in uni-axial tensile test. So that is how, thank you from me.