Maintenance and Repair of Concrete Structures

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Lecture – 05
TM-Ring Test for Assessing: The Quality of TMT / QST Steel Rebars

Hi, welcome to this short video on air quality control test for most of the rebars which are available in our country. Thermo mechanically treated steel or rather technically known as quenched and self-tempered steel. We use this steel a lot in our construction site. However, there are a lot of issues associated with the quality of this steel. Recently we developed and rather modified the test procedure on how to assess the quality or how to assess the tempered Martensite ring on TMT steel. And I have here Suraj Nair who is a masters student who worked on this project and then refined the test procedure. So I am actually handing over to him to explain the significance of this test, why it is necessary for our country and then explain the details of the test methods.

Hi, my name is Suraj and I worked as a graduate student at IIT Madras developing the TM ring test which is used who assess the quality of the TMT rebars in terms of its microstructure. Now as shown on the screen, the TMT rebars are special in having a cross section where a tempered Martensite ring and a ferrite pearlite (FP) core in it. The tempered Martensite ring is predominantly responsible for the strength that the TMT rebars have whereas the ferrite pearlite core gives it its ductility.

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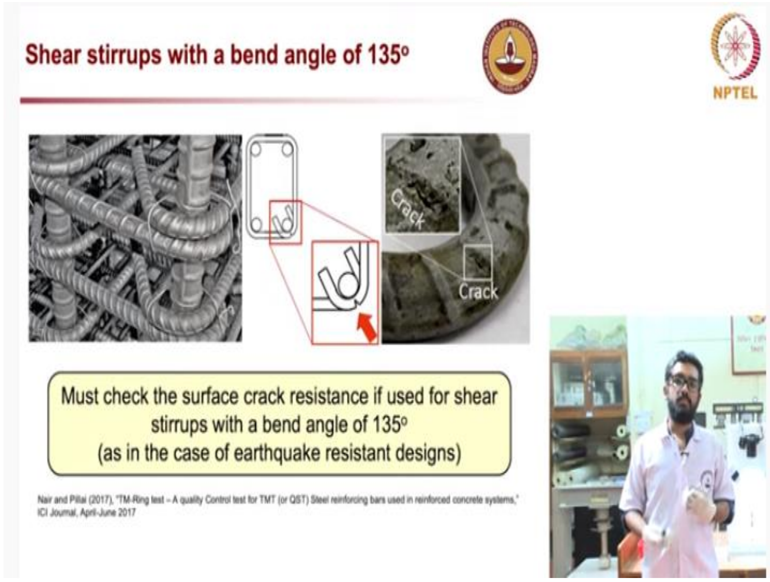

Because of its special feature, we use these in earthquake resistant designs where we need both strengths and used in ductility. These parts are used in stirrups and we bend it at 135 degrees. A typical 135 degree bent stirrup as being shown here. A good TMT rebar will show a non-cracked surface because the surface crack resistance is also good in these cases. But surprisingly as shown on the screen we found cracks in several rebars which have been tested in bending and this is being attributed to the inadequate microstructure that is present in it.

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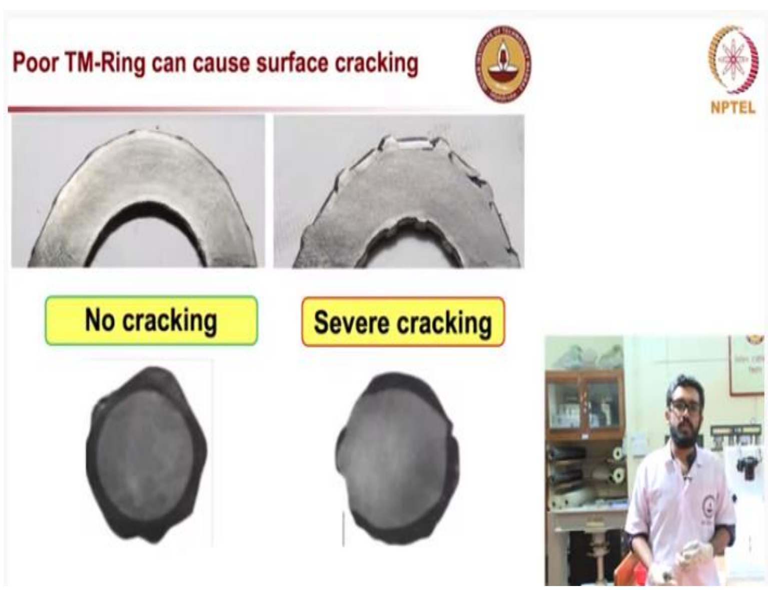

When I say inadequate microstructure as shown on the screen, you can see that no cracking case shows a complete TM ring in it with a concentric FP core whereas a severe cracking case has an incomplete TM ring in it which shows cracking when it is being subjected to bending.

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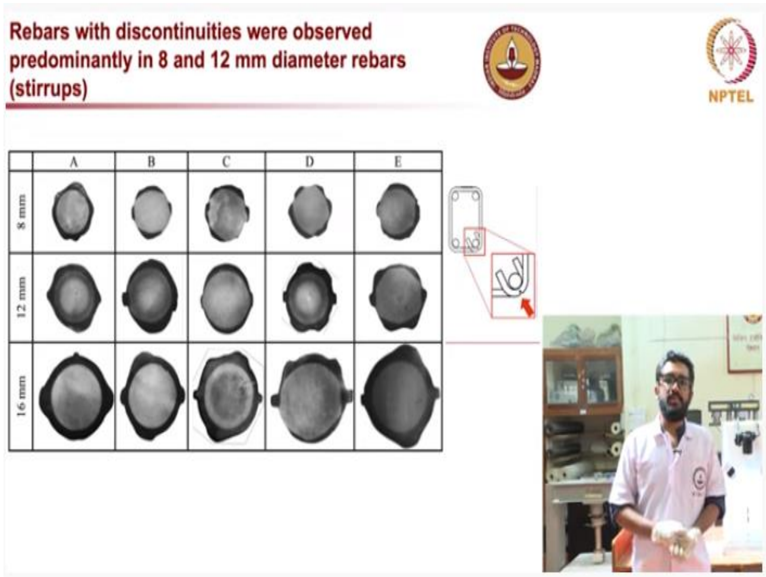

Now we have tested this in several rebars of different diameters and different sources. So, on the screen we have several different rebars being tested and show us the TM and the FP areas in it. So in most of the cases we find that the microstructure is inadequate where the TM ring is discontinuous, or the FP core is eccentric, and this is predominantly seen in 8 mm and 12 mm rebars. Now if we don’t ensure the proper microstructure is present it can result in premature failure in terms of strength or premature corrosion.

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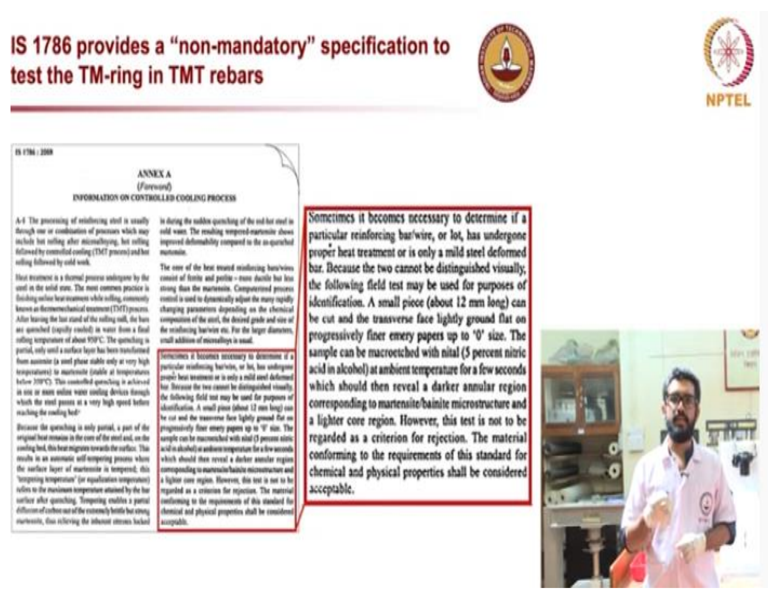

IS 1786 which regulates the strength characteristics of these bars do mention about doing a macro etching test which is non-mandatory to make sure that the TM ring and the FP core are properly present in these rebars. But since it's not mandatory it's not usually followed or not used as an acceptance criteria in the specifications.

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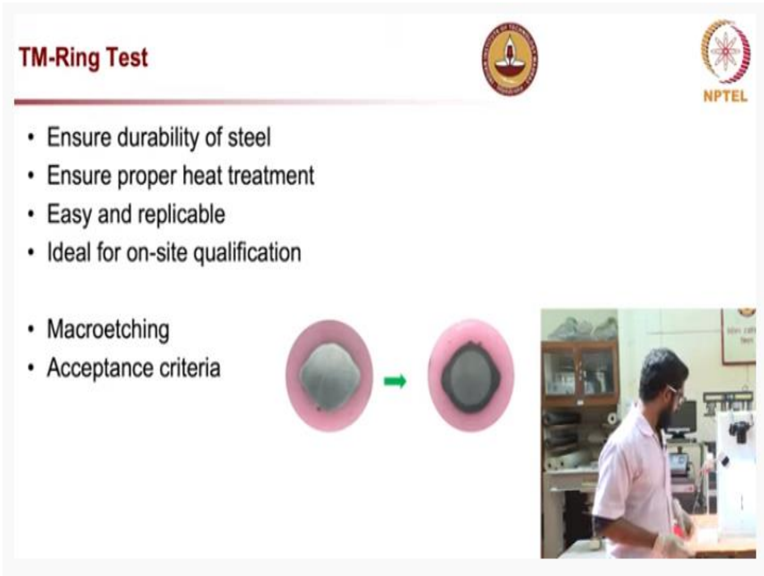

This is where TM rink test comes into picture where it used to ensure the durability of the steel in terms of proper heat treatment. This test is easy and replicable to do on site and it involves macro etching in it. This is more of an enhanced version of macroetching.

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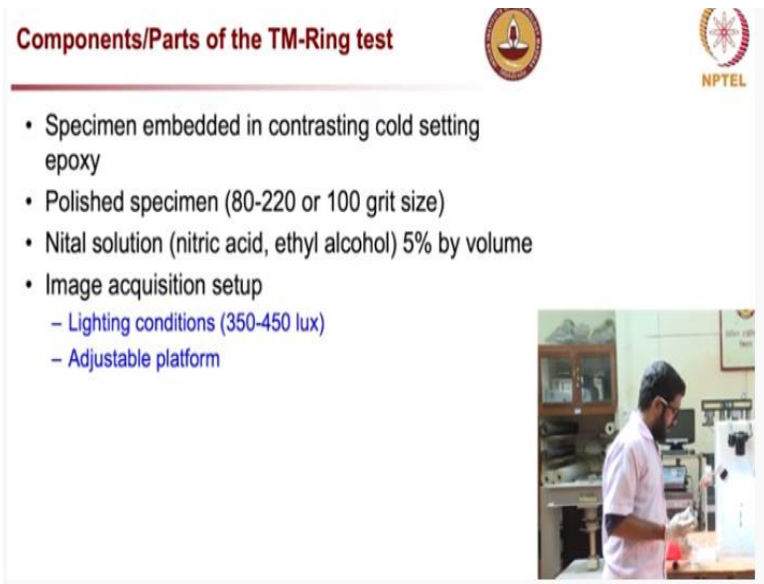

Coming to the test procedure, we have two parts, one is the specimen preparation and second one is the actual test procedure. For the specimen preparation we have a regular steel rebar which is cut into a small piece, this rebar will be polished using sandpapers of different grid sizes ranging between 80 to 220. Once polished we embed the specimen in a cold mounting epoxy which in this case has a contrasting color, this will help at the end when we take the photograph.

Coming to the test setup, we have a camera which is set at the top, we have two adjustable lighting and then there is a movable platform. On the movable platform stays the specimen. The adjustable lighting is set at 350 to 450 lux light intensity to make sure that we have replicable results. The movable platform is set to make sure that the specimen is entirely in focus in the camera.

Next, we have the solution which we are going to use for macro etching which is 5% Nital solution. The Nital solution is being made using nitric acid and ethyl alcohol. 5% nitric acid by volume in ethyl alcohol is being used in here.

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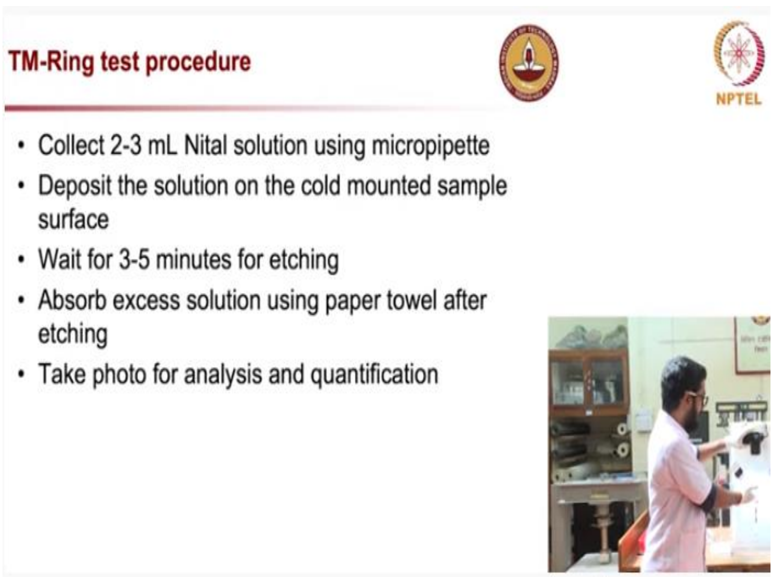

Once a solution is ready, we collect it using a micro puppet, take 2 to 3 ML and pour it on the surface of the specimen. Once a specimen is exposed to the Nital solution, wait for 3 to 5 minutes within which the specimen is going to be etched. Having etched we will collect the excess solution on the surface of the specimen using paper towel or cloth. This is to make sure that the surface is non-reflective when you take the photo. So now the TM and FP areas are clearly visible and then we take a snap at the specified lighting condition and the proper focus level.

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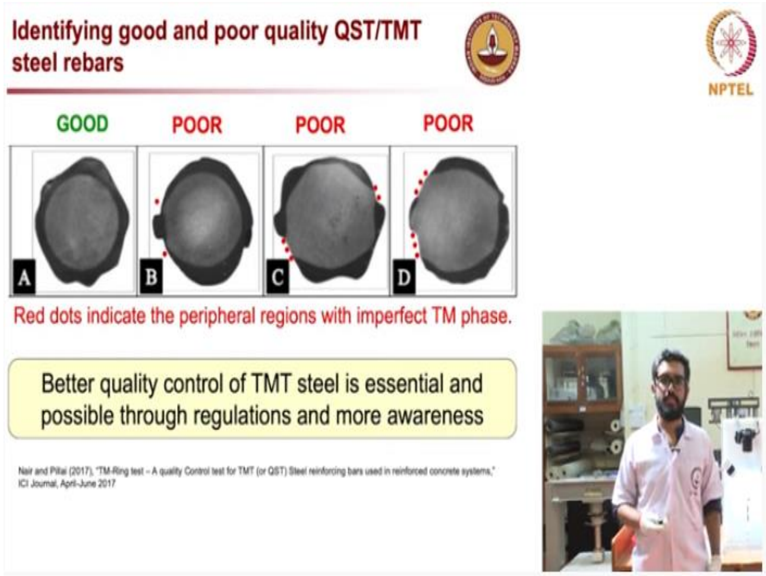

So as shown on the screen the result of this test it would be different cases. Case A is good where you find a completely TM ring and an FP core whereas cases B, C, and D are poor TMT bars where an incomplete TM ring is present, or an eccentric FP core is present. This can have implications on the strength and corrosion characteristics.

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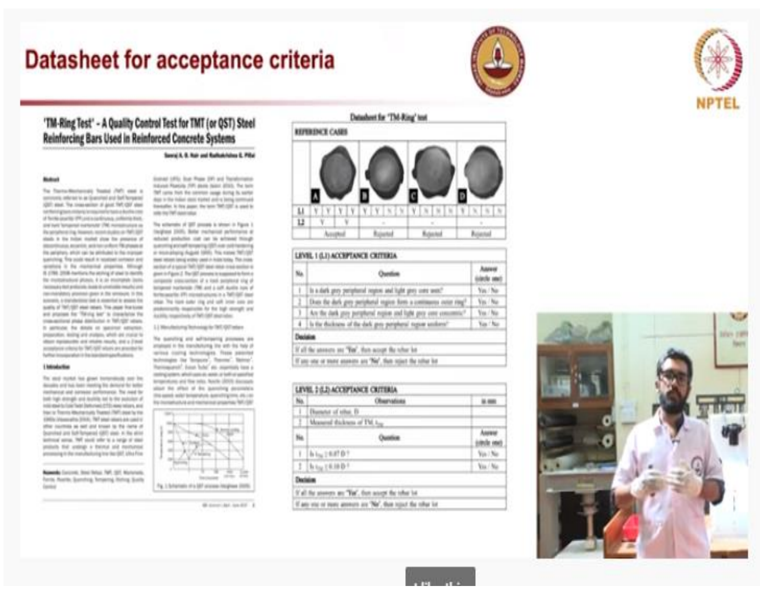

This test procedure and qualification or acceptance criteria has been published in a recent paper by us in ICA journal. So on the screen the name is again TM ring test and there is a data sheet that is present in there which can be used on site for acceptance criteria. The acceptance criterion is of two levels. Level one is a visual analysis where we visually see if the TM ring is continuous or the FP core is concentric. Level two is a much more extended analysis where we quantify the area of the tempered martensite using any image analysis software.

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The quantified TM area is expected to be in the range of 30 to 50%, an under quench TMT rebar will have an area of tempered Martensite less than 30% which can result in premature strength failure or corrosion and an over quench case where tempered Martensite is grater than 50% of the area can compromise in ductility.

So we need to make sure that the area is within 30 to 50% and this can be done using the level two acceptance criteria. With that the test set up, the specimen preparation and the testing procedure has been explained and this is easy to follow on site and can be helpful to make sure that the quality of the TMT steel rebars are ensured. Thank you.