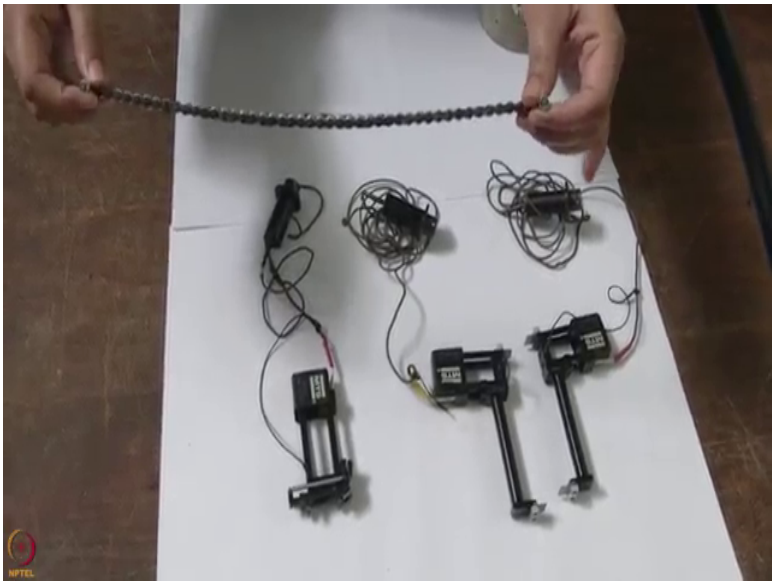
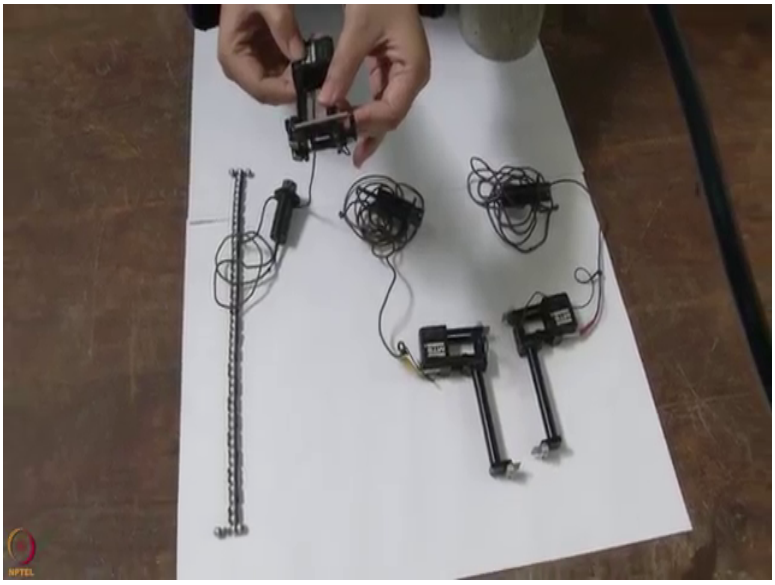
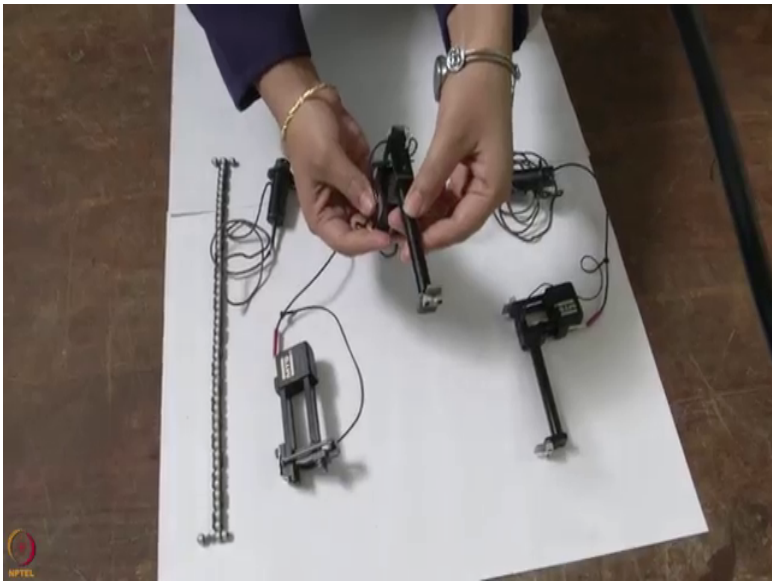
**The Advanced Topics in the Science and Technology of Concrete**
**Steffi J Stephan**
**Indian Institute of Technology Madras, Chennai**
**Strain Softening Response of Concrete under Uniaxial Compression**

Hello everyone welcome back to the session on closed-loop testing, I am Steffi J Stephan, Ph.D. student working in the Department of civil engineering, today I will be showing how the testing of compression is done in the closed-loop testing machine, here will be getting the complete stress strain curve of concrete under compression, so we need a cylindrical specimen for this and that I mention of the specimen should be maintain in such a way the height to diameter ratio is always less than two and the testing is mainly controlled by means of circumferential strain control.

(Refer Slide Time: 0:59)

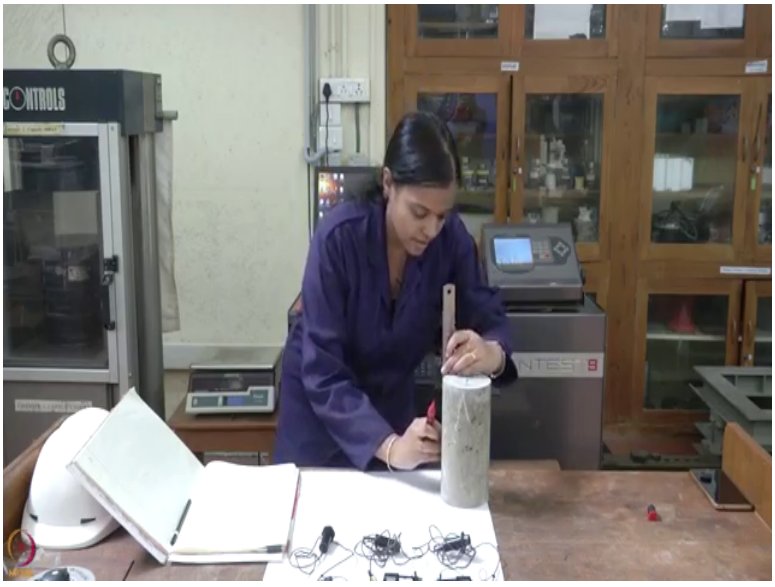


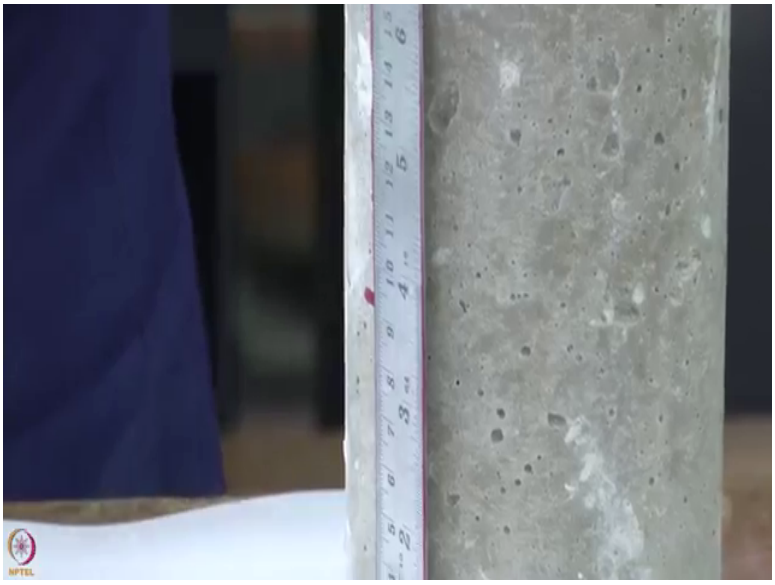


In order to maintain stability during the testing process, so these are the accessories required to do the testing, we have undeformable chain which will be placed around the specimen and extensometer will be connected to this chain to record the change in cord length, we have two axial extensometer, which will record the axial defamation of the specimen.

(Refer Slide Time: 1:38)

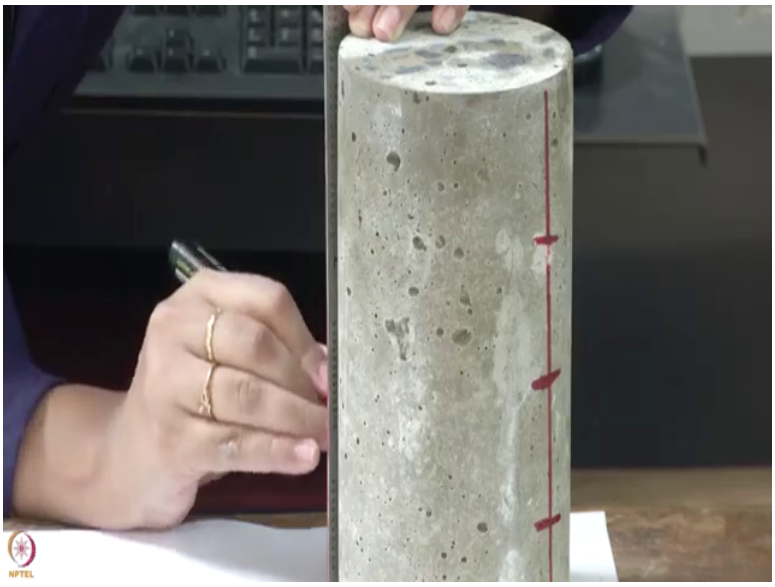






So before starting the test you have to measure the diameter, initial original diameter of the specimen and we are measuring the height of the specimen, now we have measure the height and diameter of the specimen, now I will mark the specimen to attach the extensometer, so we draw a straight line and will mark the centre of the specimen, in a case it is 195 MM, so I will be marking the centre of the specimen, then in order to attach the extensometer, the extensometer gauge length is 100 MM.

(Refer Slide Time: 3:02)

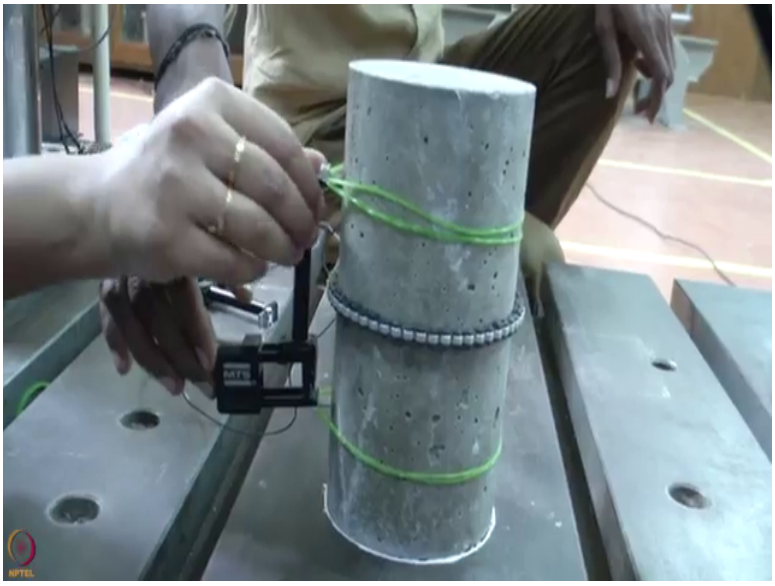



So I will be marking 50 MM above and 50 MM below the centre point, so similar way we will mark on the opposite side, now the specimen is marked, I will take the specimen to the testing system and start the testing.

(Refer Slide Time: 3:46)

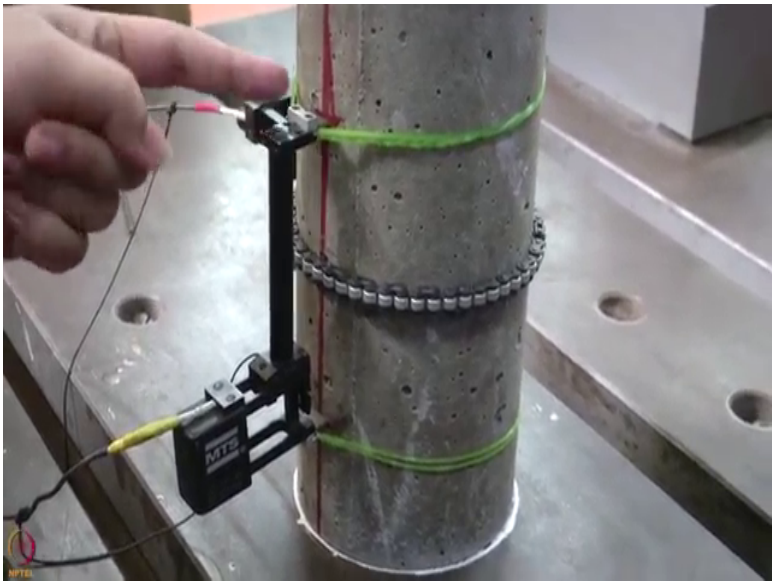

So this is the closed-loop testing machine in which we will be doing the compression test, this cross cade can be manually moved by means of this manual controlled lever arm, the capacity of the machine is 1000 kg newton, which is powered by hydraulic unit, the actuator can be moved with the help of the software in the system, so you, we also have a LVDT above the actuator, which measures the movement of the piston, now you will attach the extensometer on the specimen.

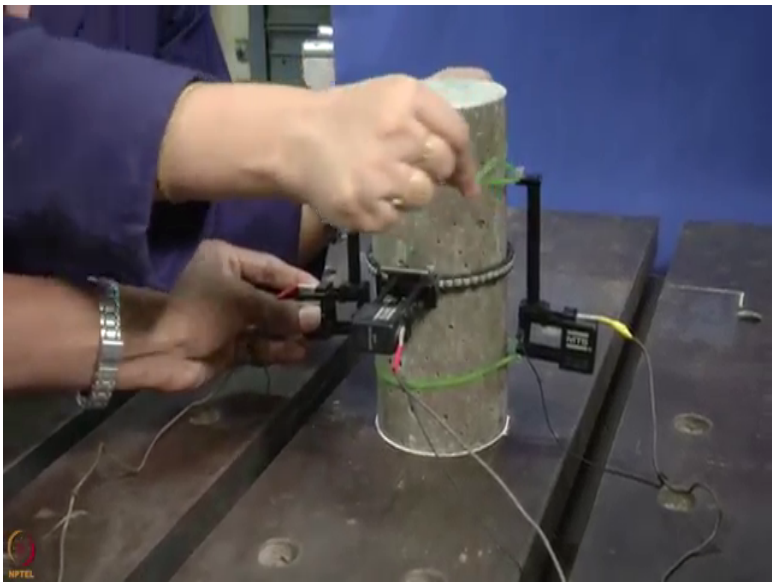
(Refer Slide Time: 4:18)



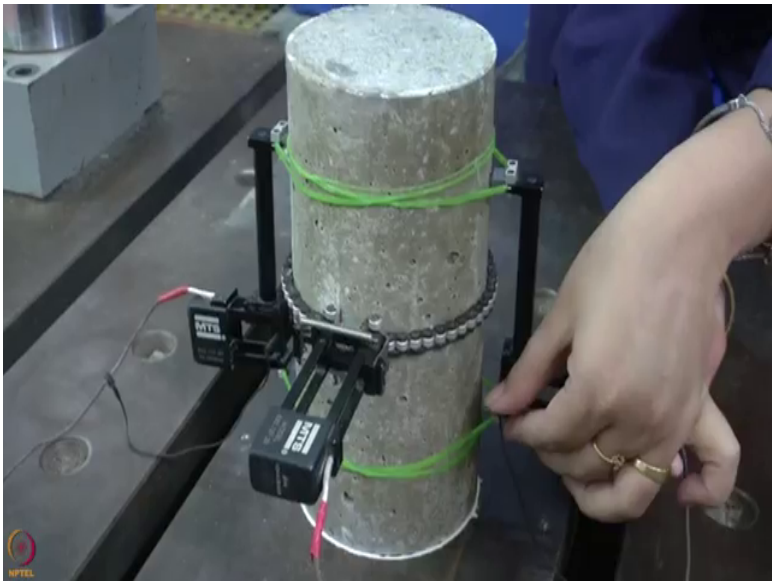
So the when end of the chain will be attached to the extensometer and will place the chain around the specimen, now we have to elongate the extensometer, so that we can connect the other end of the chain, check whether the chain is kept at the centre of the specimen, will place the extensometer on the markings, so by using a rubber band we are fixing the extensometer in-place.

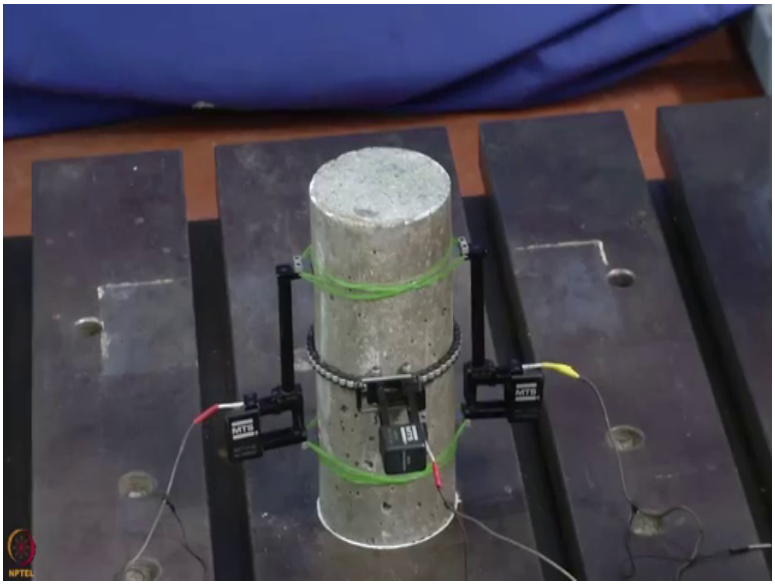
(Refer Slide Time: 6:05)






MTS
MTS
MTS


MTS
MTS

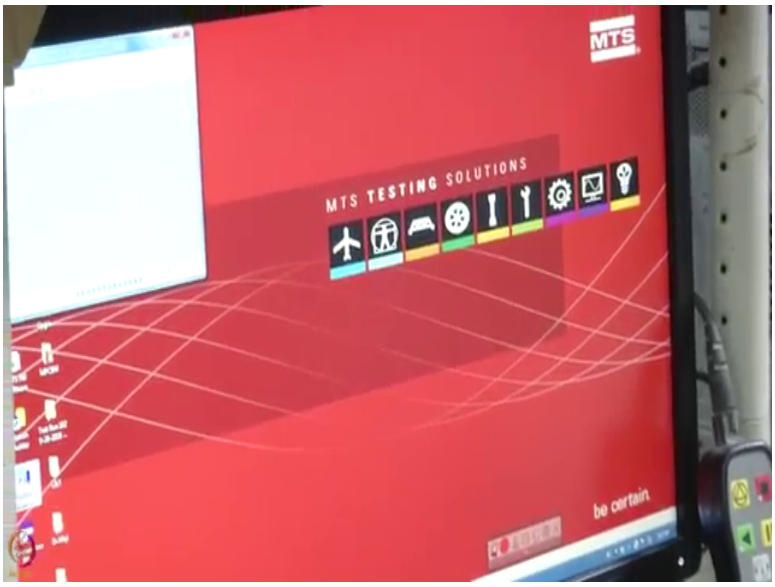

MTS
MTS

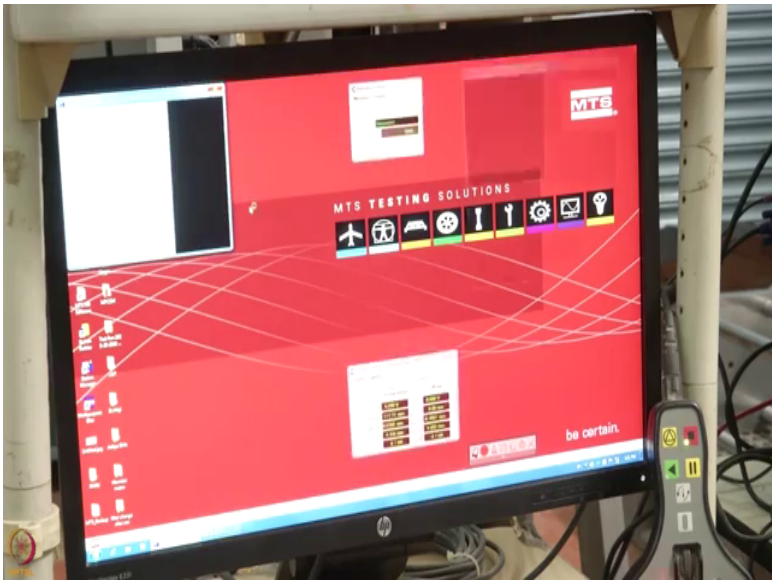
The blades of the extensometer should be placed on the markings, similarly we are placing the another extensometer, while placing the extensometer make sure the pin on the extensometer and before starting the test, you have to remove this pin, so that the extensometer deforms.

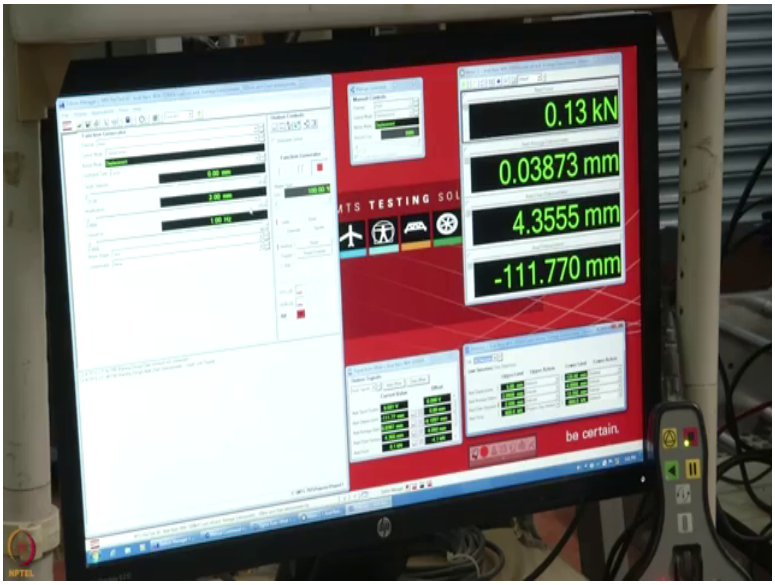
(Refer Slide Time: 7:36)

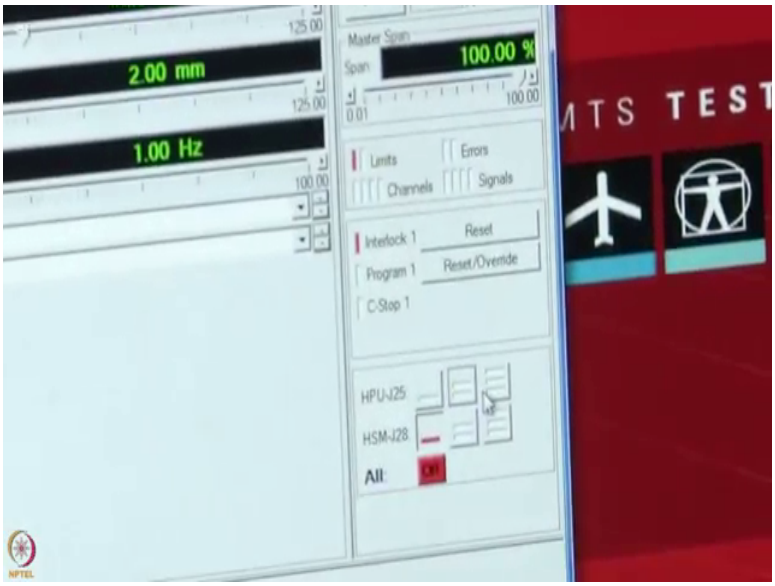
Now the testing setup is ready, the circumferential strain is going to be measured by this extensometer and the axial defamation is going to be measured by these two extensometers, in this test will control the testing by means of the circumferential control, this is done because the circumference is going to always expand whereas the axial defamation will always compressed but what happens is if there is a crack occur near the extensometer, the extensometer might slip of that is why we are using this circumferential control in this testing.

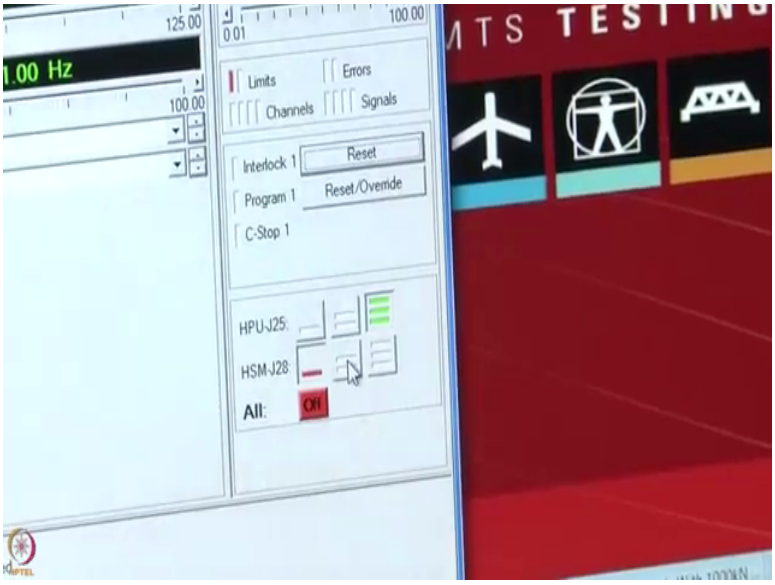
(Refer Slide Time: 8:13)

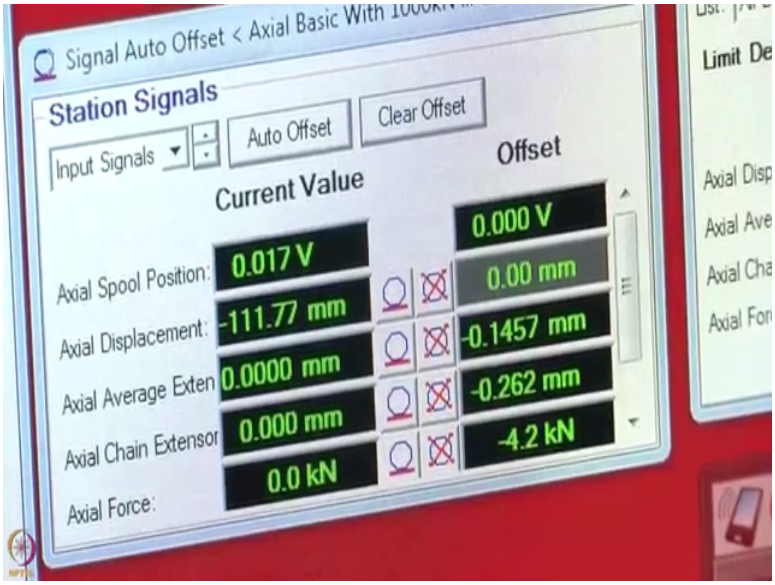


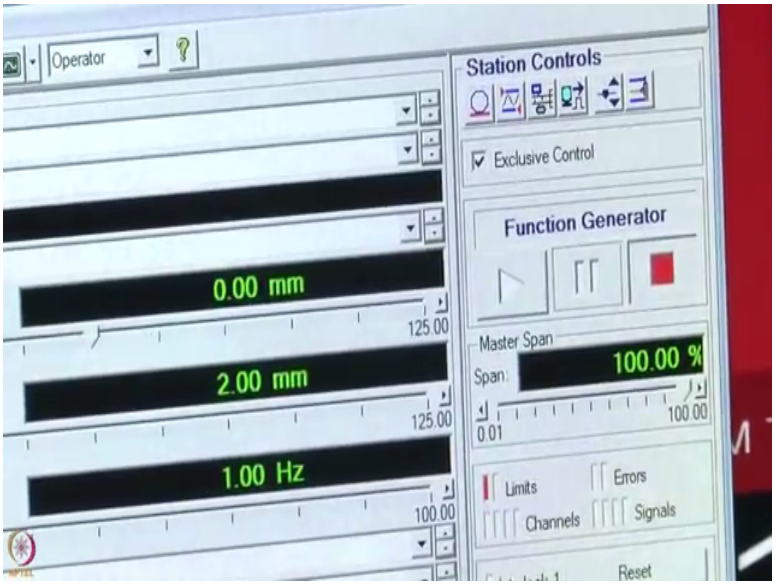

MTS TESTING SOLUTIONS
be certain.

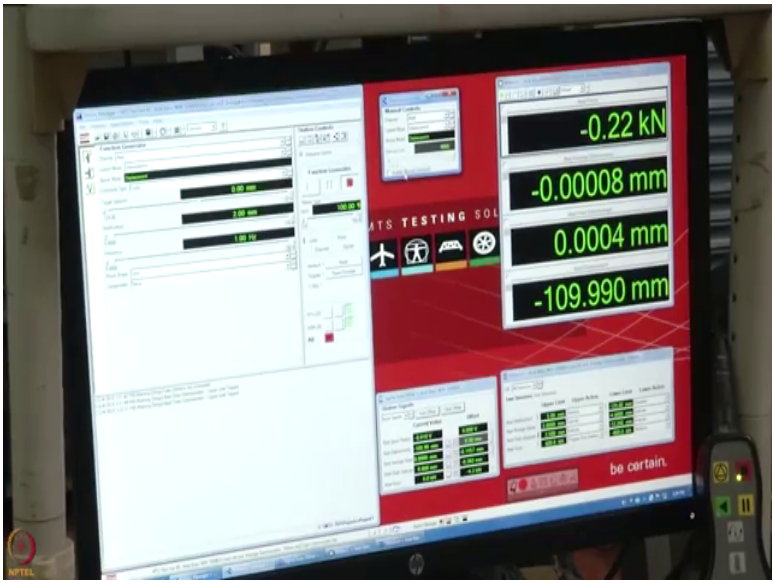

0.13 kN
0.03873 mm
4.3555 mm
-111.770 mm
be certain.


2.00 mm
1.00 Hz
Master Span
Span
100.00 %
Limits
Errors
Channels
Signals
Interlock 1
Reset
Program 1
Reset/Override
C-Stop 1
HPU-J25
HSM-J28
All
MTS TEST


1.00 Hz
125.00
100.00
0.01
Limits
Errors
Channels
Signals
Interlock 1
Reset
Program 1
Reset/Override
C-Stop 1
HPU-J25:
HSM-J28:
All:
Off
MTS TESTING

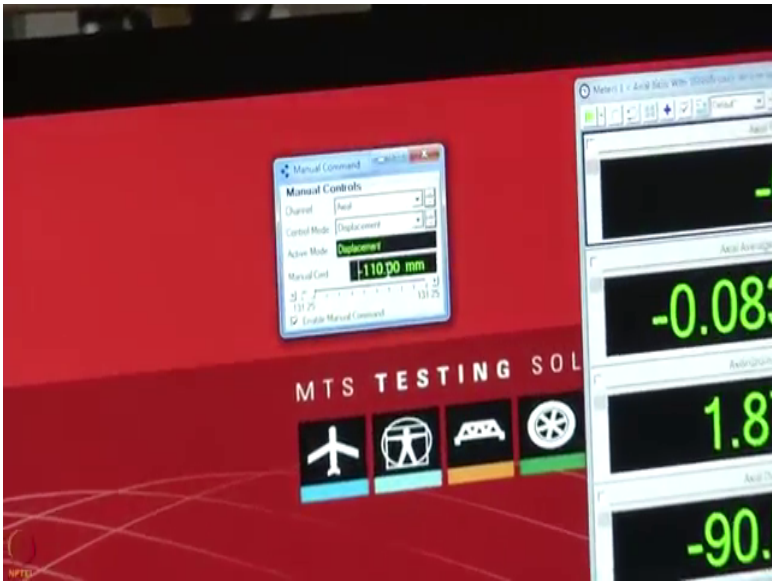

Signal Auto Offset < Axial Basic With 1000kN
Station Signals
Input Signals
Auto Offset
Clear Offset
Current Value
Offset
Axial Spool Position:
0.017 V
0.000 V
Axial Displacement:
-111.77 mm
0.00 mm
Axial Average Exten
0.0000 mm
-0.1457 mm
Axial Chain Extensor
0.000 mm
-0.262 mm
Axial Force:
0.0 kN
-4.2 kN
Limit De
Axial Disp
Axial Ave
Axial Cha
Axial For


Operator
Station Controls
Exclusive Control
Function Generator
0.00 mm
125.00
2.00 mm
125.00
1.00 Hz
100.00
Master Span
Span:
100.00 %
0.01
100.00
Limits
Errors
Channels
Signals
Reset

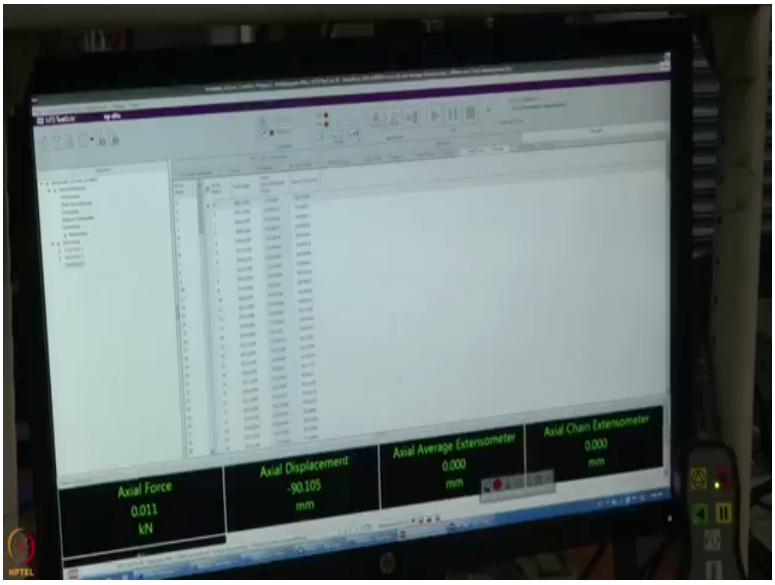


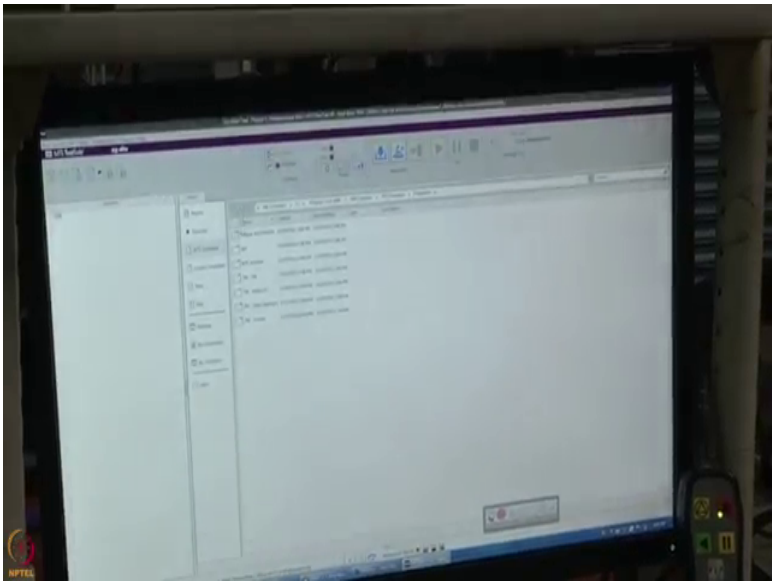

So first the controller has to be switched on, after that will open the software called Station Manager which will control the testing, so this is the software used for the testing, first let to switch on this exclusive control, so that we can use these two icons, first we will switch on the hydraulic power unit which supplies the oil to operate this machine, then will be switching on the HSM.

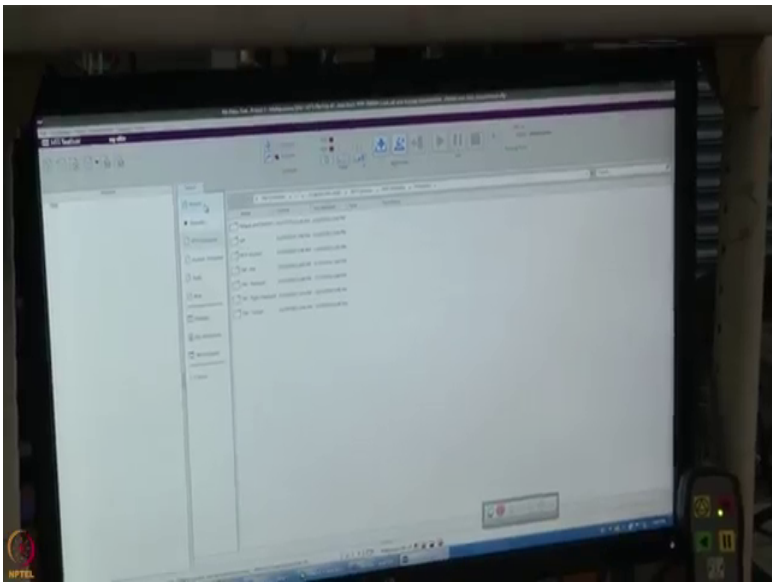
(Refer Slide Time: 10:04)

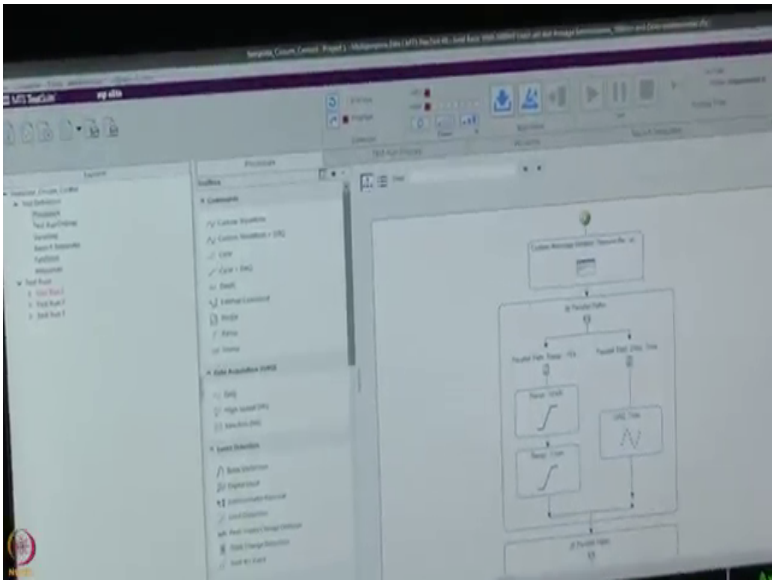

Manual Command
Manual Controls
Displacement
-110.00 mm
MTS TESTING SOL
-0.08
1.8
-90.


0.02 kN
-0.00000 mm
0.0001 mm
-90.102 mm
MTS TESTING SOL
be certain.


Axial Force
0.011
kN
Axial Displacement
-90.105
mm
Axial Average Extensometer
0.000
mm
Axial Chain Extensometer
0.000
mm

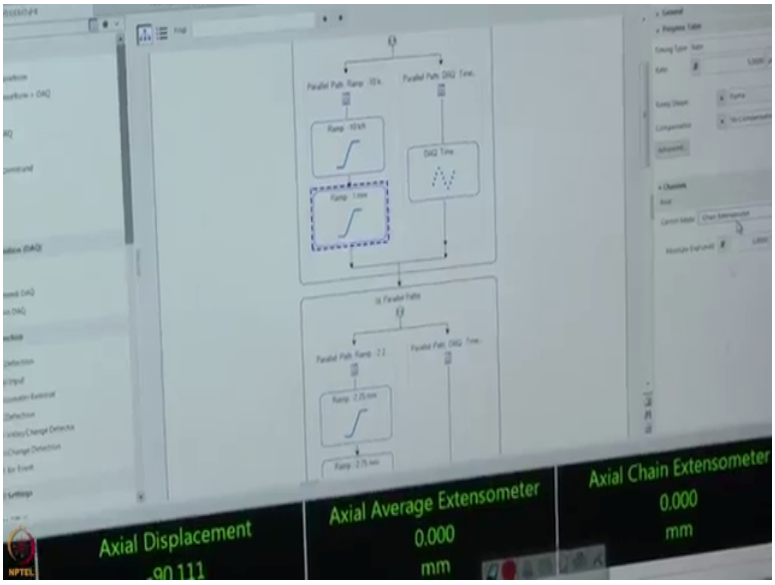


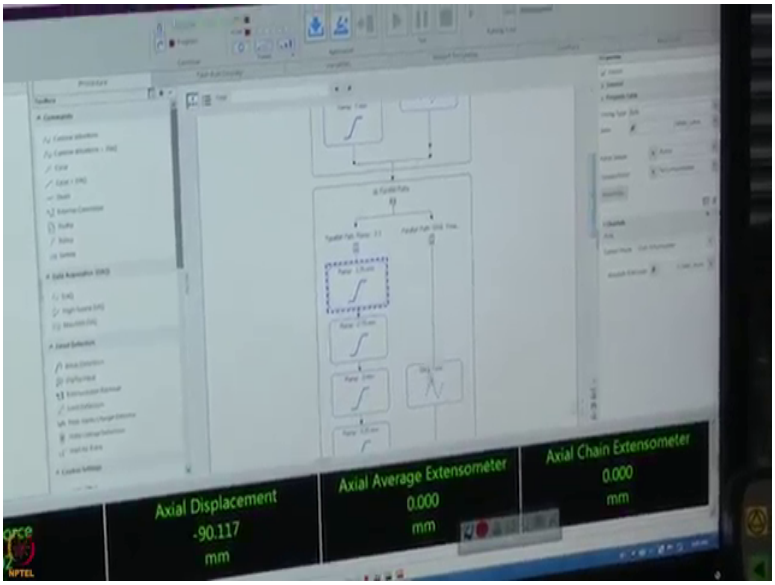


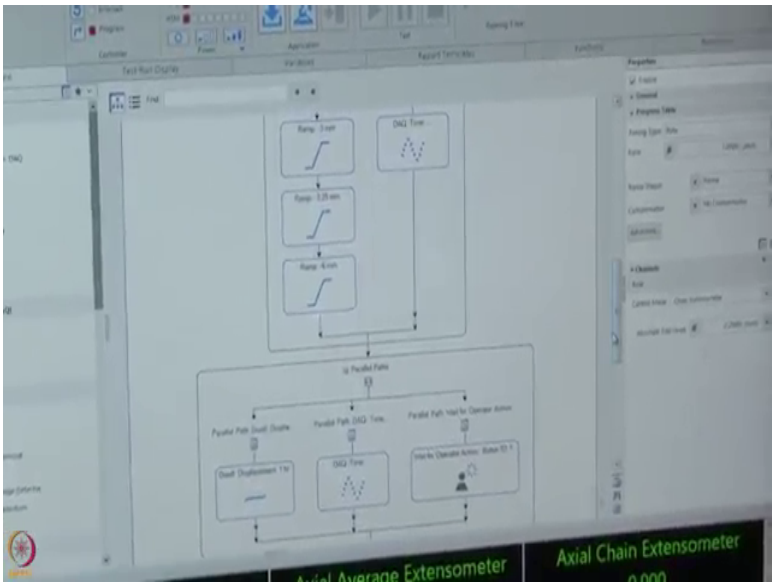


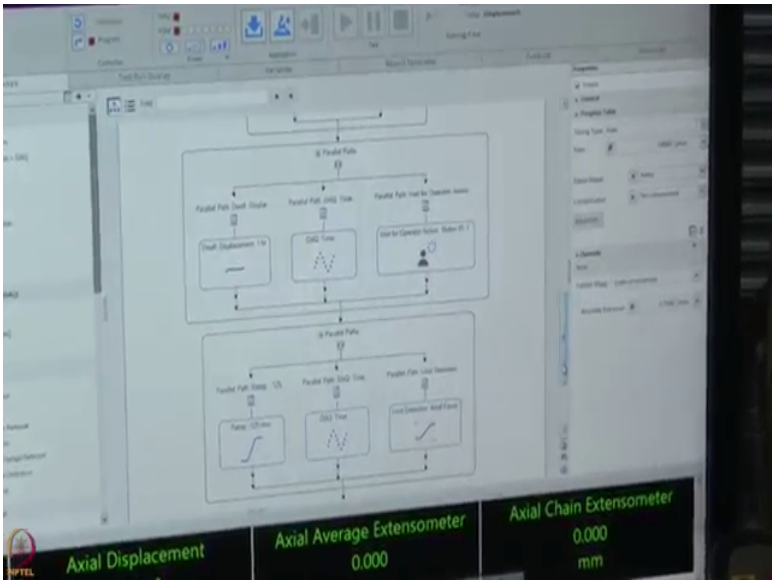
We are placing the piston at 110 MM that by the piston if, due to some instability comes down also, it does not hit the ground, this is for safety purpose than now will open another software called multipurpose elite, we are opening a template which is already programmed, in this software we can program the steps to be done during the testing.

(Refer Slide Time: 11:20)


Axial Displacement
Axial Average Extensometer
0.000
mm
Axial Chain Extensometer
0.000
mm

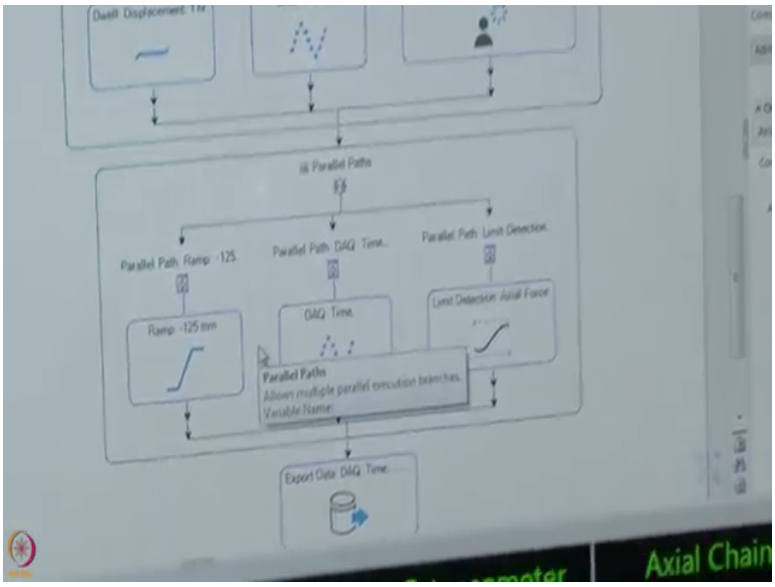

Axial Displacement
-90.117
mm
Axial Average Extensometer
0.000
mm
Axial Chain Extensometer
0.000
mm

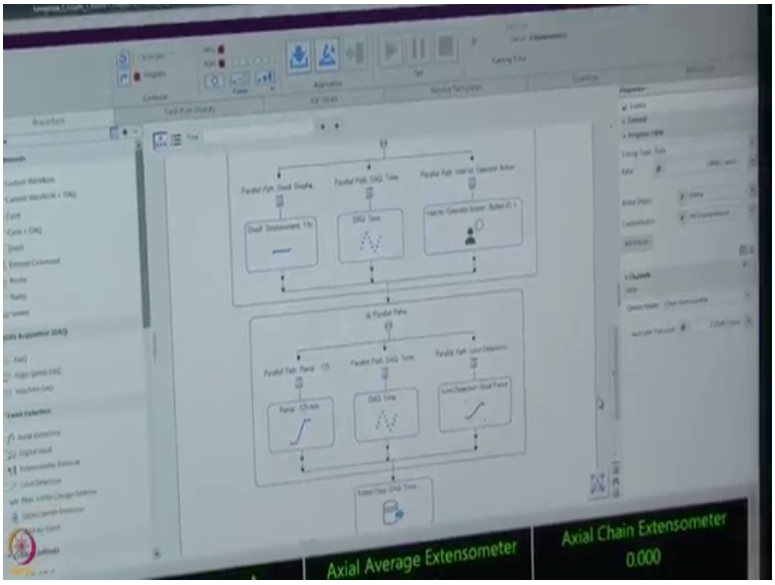

Axial Chain Extensometer




First initially the test will take place under load control, then we will be switching onto the chain extensometer that is circumferential control, we will be gradually increasing the rate of loading and the data will be upward in each step, defamation of about 6 MM, then the test will stop and the piston will remain in the same position, in the meantime they will be removing all the extensometer from the specimen.

(Refer Slide Time: 11:59)



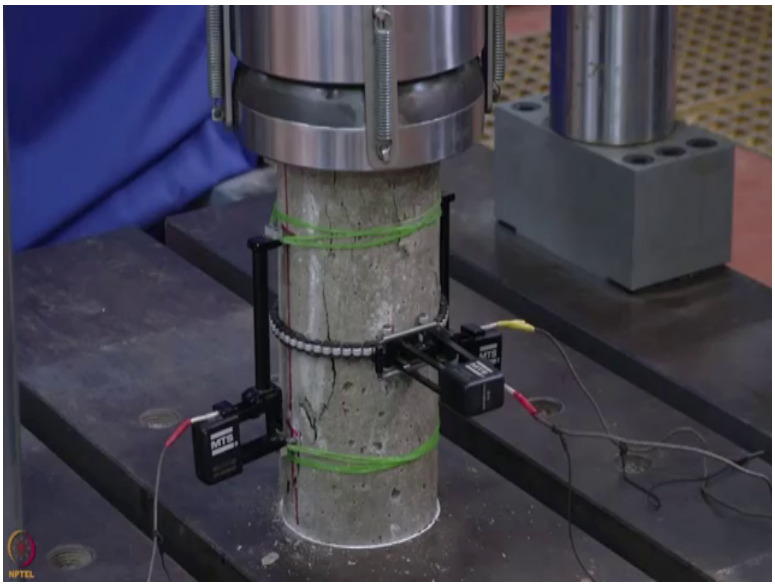


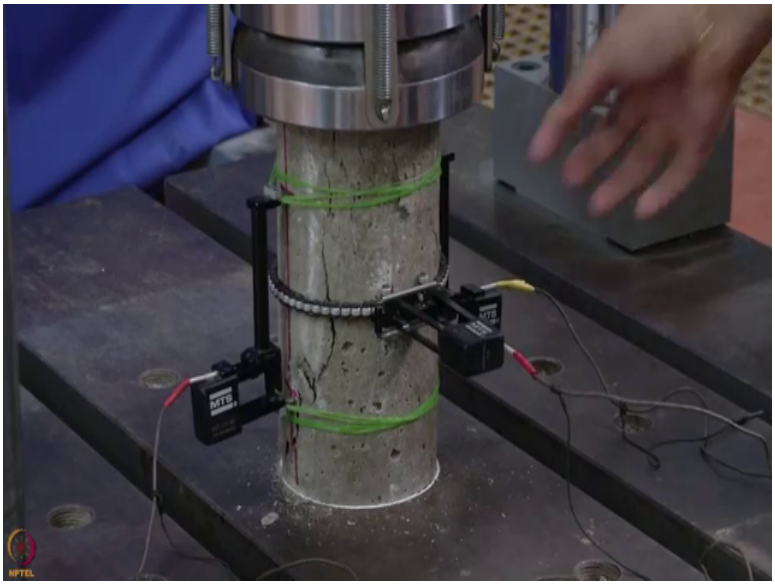

Then after that the test will start and the piston will keep on moving, now it will be the piston defamation controlled, so once the load has reached to 0.5 kg newton, the test will stop.

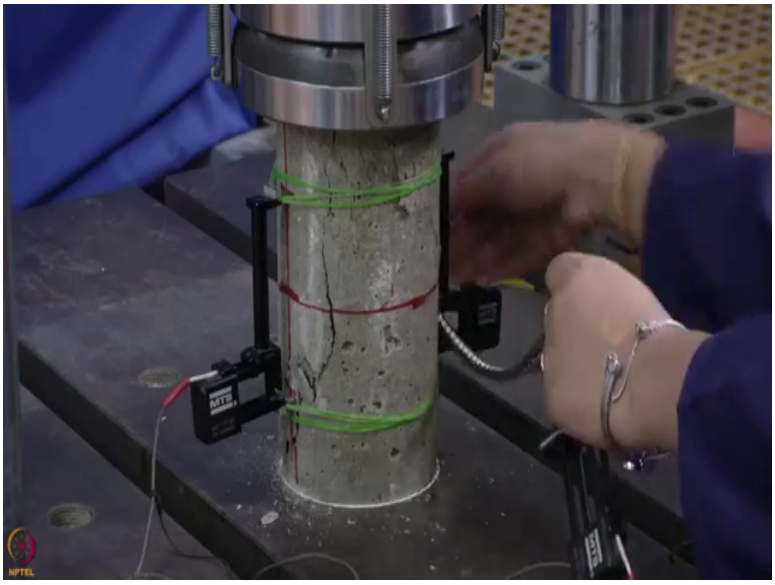
(Refer Slide Time: 12:16)

The specimen should be grinder or capped before testing, in order to make sure the surface is smooth otherwise there will be irregularities in the specimen because of casting and stress concentration might occur and you will not have uniform loading on the specimen.

(Refer Slide Time: 12:36)

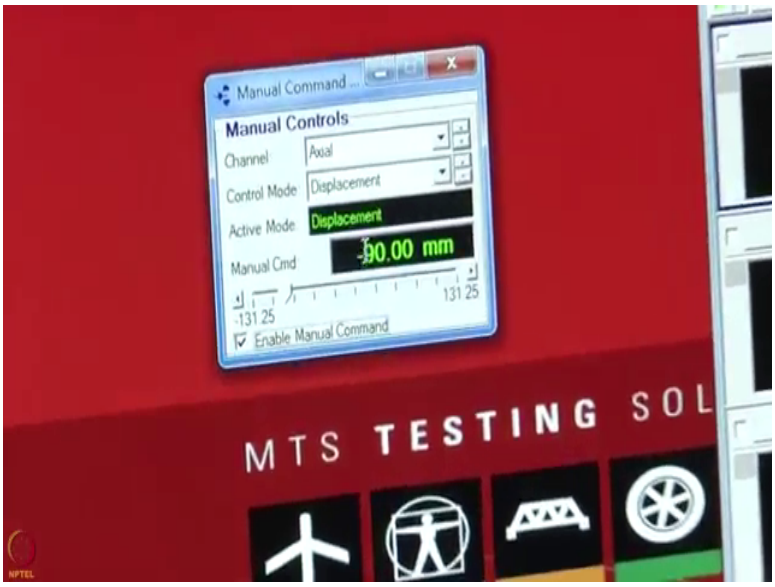







MTS

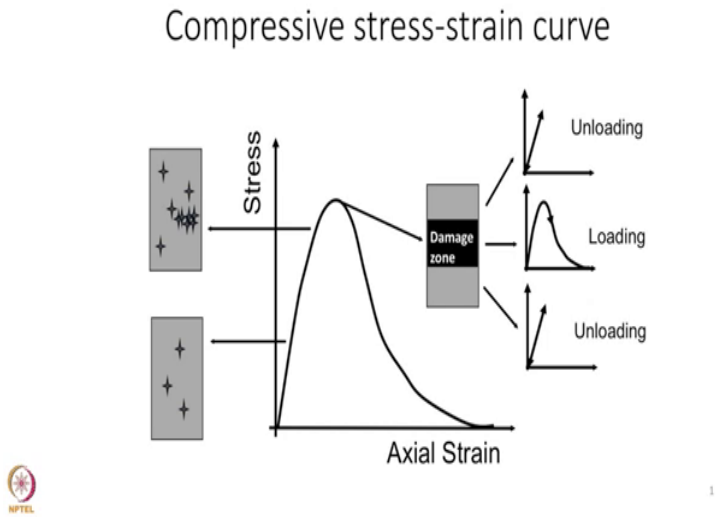
(Refer Slide Time: 17:56)




So before starting this test, we have to always ensure the active mode is displacement in the manual command, then we will move the piston to 110 MM, now the testing is complete, from this test we will be, we can derive the ex-models of concrete, you can drive ex-models of concrete from the linear region and you can calculate the compressive strength of concrete by using the axial and circumferential strain, you can calculate the piossons ratio and you can also calculate the compressive toughness which is the area under the complete stress strain curve.

In conventional testing procedure this type of result is not possible, where you can get the complete stress strain curve by using closed-loop testing, you can have a stable control and get the complete stress strain curve.

(Refer Slide Time: 18:59)




From this graph you can see first initially the stress is gradually increasing, linearly with strain and then it is kind of having a non-linear behaviour when the micro cracks are occurring, then this cracks, micro cracks joins together and form a single crack and crack localisation occurs when the peak load is reached, then after the peak the stress gradually drops down and the test is continued, complete failure.

So now you know the major advantage of closed-loop testing and using this kind of test, you can find the complete compressive behaviour without omitting in the useful part, useful post peak part of the concrete or any type of specimen and you can do design accurately. Thank you, thank you for listening.