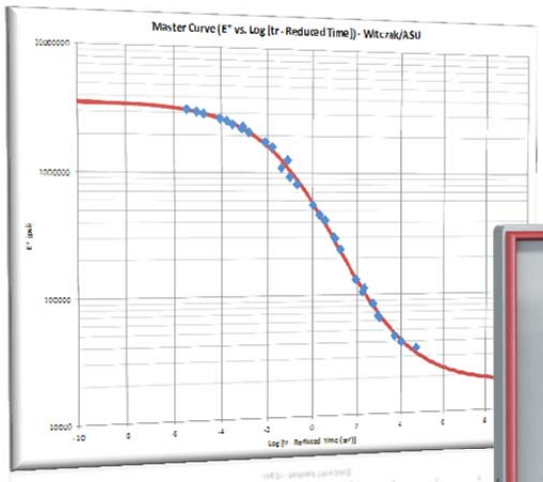
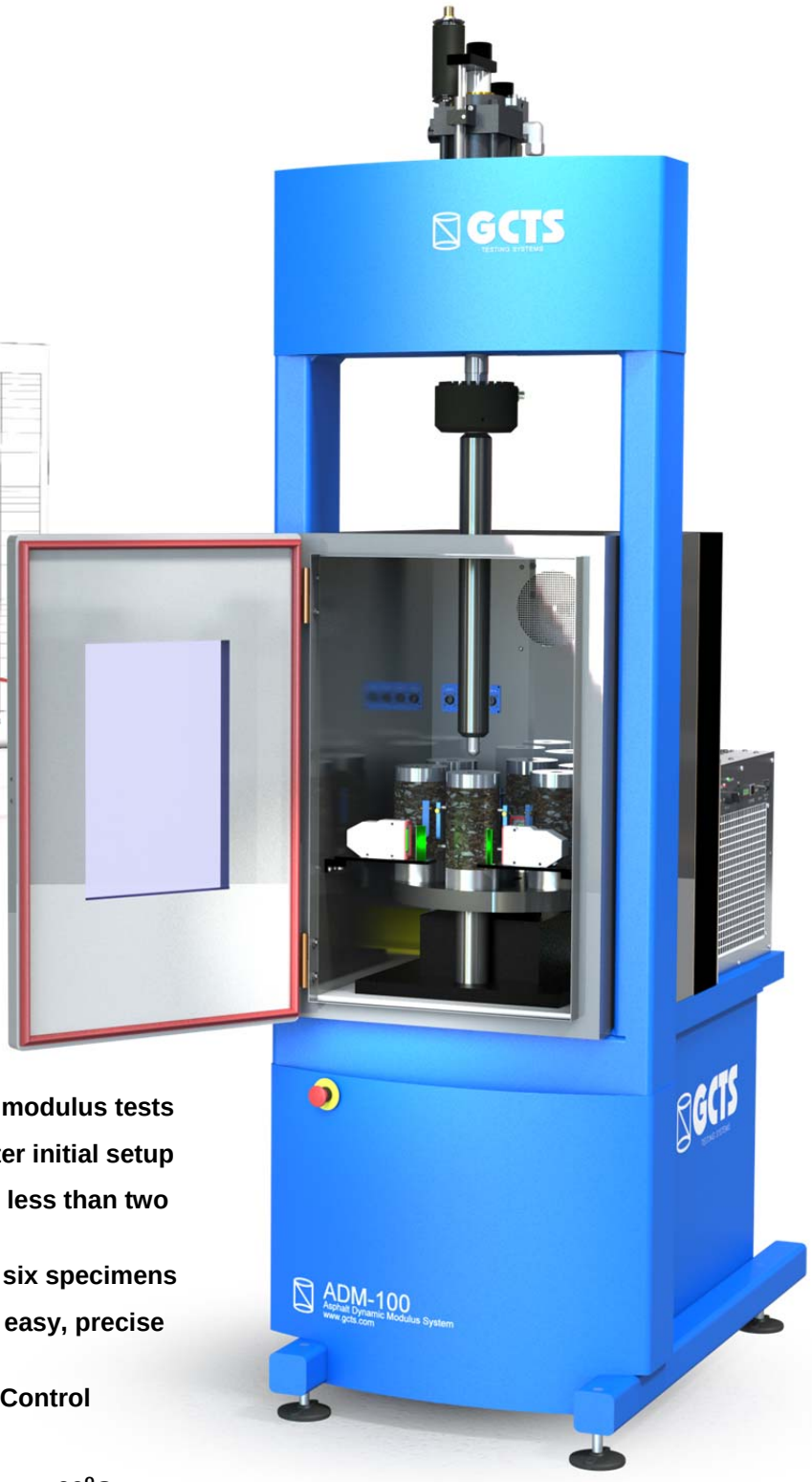
GCTS is committed to designing accurate testing systems by integrating innovative software engineering with advanced hardware. GCTS systems perform at the highest levels of reliability, providing efficient systems that satisfy customer needs and expectations.

GCTS TESTING SYSTEMS

ADM-100
Automated Dynamic Modulus System





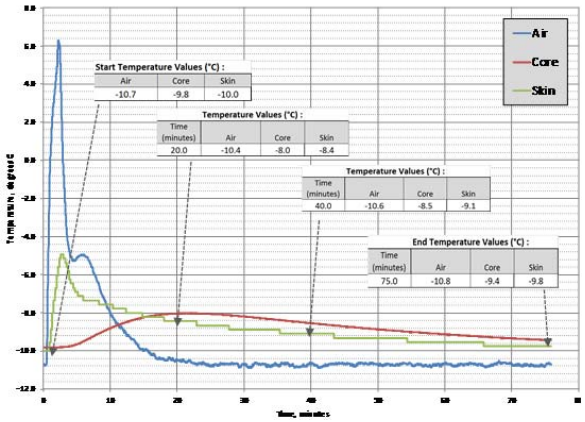
- **Completely automatic dynamic modulus tests**
- **No user intervention needed after initial setup**
- **Full Master Curve generation in less than two days**
- **Automatic rotating table to test six specimens**
- **Optical micrometer sensors for easy, precise measurements**
- **Electro-Hydraulic Digital Servo Control**
- **Frequencies up to 80 Hz**
- **Temperature control from -10°C to +60°C**

DESCRIPTION

The GCTS ADM-100 Automated Dynamic Modulus Testing System is unique in that it can perform an entire dynamic modulus test on up to six specimens without requiring any input from the operator. After the initial setup, the operator is free to leave the room, as the system will automatically set the environment to the right temperature, determine the loading stress at each temperature, perform the test, then rotate the next specimen into place to be tested. This complete automation ensures that the environmental chamber door does not need to be opened during the test, drastically reducing the amount of time needed to generate the Master Curves. Since this system is fully automated and can be run overnight, two full Master Curves (one for each set of three replicates) can be created in just two days.

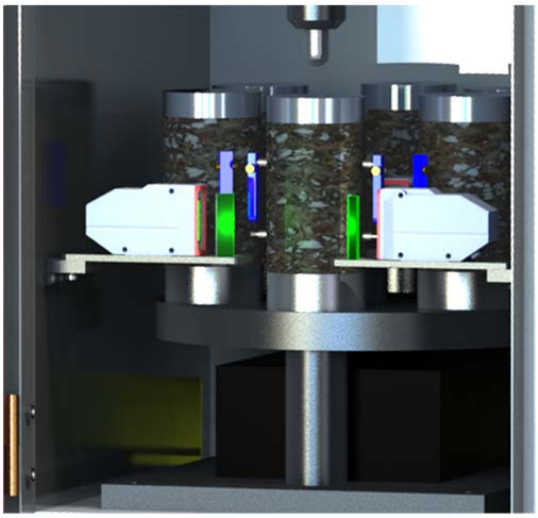
The Dynamic Complex Modulus is an important property of HMA mixtures, as it is used to determine both the linear viscoelastic and elastic properties of pavement materials. The dynamic modulus |E*|, the absolute value of the dynamic complex modulus, is used to predict the permanent deformation (rutting) potential of HMA. The GCTS systems can perform this test with ease in both confined and unconfined conditions, and can automatically obtain the Master Curve.

At the center of the ADM-100 is a rotating table with space for six cylindrical HMA specimens. This table is computer-controlled and automatically rotates the specimens into position under the loading piston for testing. After the test is completed, the table rotates the next specimen into position and continues the process. This prevents the operator from needing to open the door of the environmental chamber, eliminating the lengthy amount of time needed to reestablish the temperature in the chamber before the next test can be performed. In addition, this allows the system to perform all tests needed to determine the entire master curve for each specimen mixture (two mixtures with three replicates each) without any input from the operator. By allowing the system to run during the night, all testing can be performed in approximately two days.



Temperature Variation within Specimen after Opening Chamber Door for Two Minutes

In addition to the rotating table, this system automatically centers the specimens and can determine the optimal stress needed to obtain the proper strain. Specially-designed platens ensure that the specimens are centered through the use of springs that lock the specimen in place during testing and during the rotation of the table. These platens are treated to minimize friction at the ends of the specimen in order to prevent bulging and allow uniform stresses to develop within the specimen. At the start of the test, the system conducts preliminary measurements by loading each of the specimens at 25 Hz and automatically determining a stress that will produce approximately 100 microstrain, as called for by the AASHTO standards. This is repeated for each specimen at each temperature to ensure that the measured deformation is consistent throughout testing. By performing this test automatically, the experience of the operator in deciding what stress to use for testing does not affect the accuracy of the test results.



Close-up View of Non-Contact Measurement Sensors

This system makes deformation measurements using two non-contact optical micrometers placed at 180º each. These sensors have a 16,000Hz sampling frequency, allowing them to make accurate measurements at any testing frequency up to 80 Hz. In addition, these sensors have a measurement accuracy of ±0.5µm and a repeatability of ±0.03µm. By using non-contact sensors, there is no measurement error due to friction as in traditional LVDTs, and all six specimens can be measured with only two sensors, eliminating possible mounting errors and the need to open the environmental chamber to remount the measurement sensors.

This system is supplied with an environmental chamber which houses the rotating table that the specimens are seated on. The GCTS environmental chamber is made of high-quality stainless steel and has a full-size front window. The chamber also has dual-temperature PID control loops for both heating and cooling. The chamber temperature is directly controlled through GCTS application software, providing efficient and precise temperature control, typically better than 0.2 °C. This system can control the temperature based on either the chamber air temperature or the temperature of any instrumented control specimen to ensure that the test specimens have reached the desired temperature throughout. Two temperature sensors are provided with the system that can be embedded into the core or mounted on the surface of the control specimen.

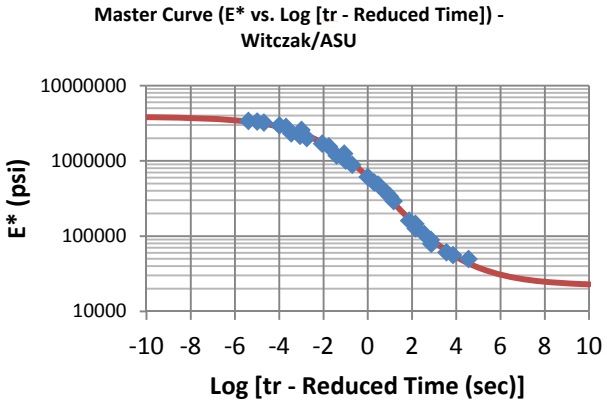
With the automatic features of the ADM-100, two full Master Curves can be created from six specimens (two sets of three replicates) in approximately two days. This system also has the capabilities needed to reduce that testing time even further, to approximately one day. This is done by reducing the number of testing temperatures to either four or three, rather than the traditional five. This can be done by expanding the range of frequencies that are tested to 0.01 Hz at the minimum and 80 Hz at the maximum. A typical specimen tested at -10°C and 25 Hz has the same modulus as a specimen tested at -6°C and 50 Hz or at -4°C and 80 Hz. By providing a wider range of testing frequencies, the ADM-100 can reduce the number of temperatures needed for testing while still capturing the endpoints of the Master Curve and retaining significant overlap between testing temperatures. The following tables provide an example for a typical specimen.

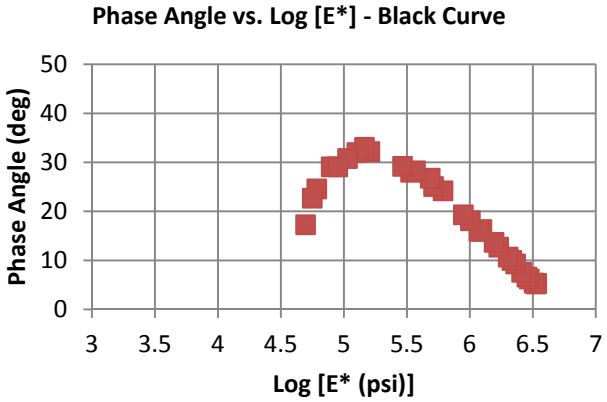
Five Temperature Test			
Temperature (deg. C)	Frequency (1/s)	Log Reduced Time	Dynamic Modulus
-10	25	-3.958	19066
-10	0.1	-1.560	9435
4.4	25	-2.822	15216
4.4	0.1	-0.424	4587
21.1	25	-1.399	8675
21.1	0.1	0.999	1309
37.8	25	0.139	2889
37.8	0.1	2.537	337
54.4	25	1.780	633
54.4	0.1	4.178	132

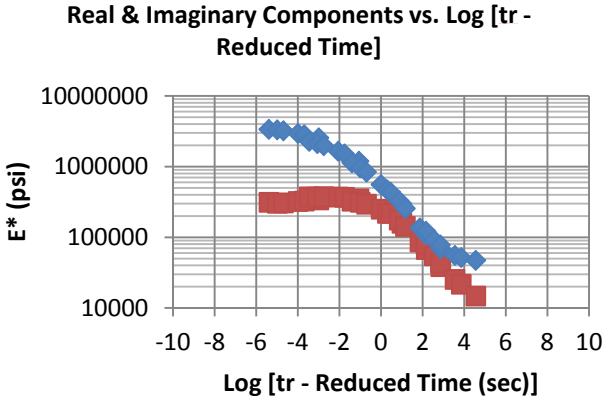
Four Temperature Test			
Temperature (deg. C)	Frequency (1/s)	Log Reduced Time	Dynamic Modulus
-6	50	-3.952	19051
-6	0.01	-0.253	4011
11	50	-2.574	14168
11	0.01	1.125	1162
28	50	-1.079	7209
28	0.01	2.620	317
45	50	0.536	2021
45	0.01	4.235	130

Three Temperature Test			
Temperature (deg. C)	Frequency (1/s)	Log Reduced Time	Dynamic Modulus
-4	80	-4.000	19179
-4	0.01	-0.097	3532
20	80	-2.001	11544
20	0.01	1.902	568
45	80	0.332	2435
45	0.01	4.235	130

At the core of the GCTS ADM-100 is our dynamic modulus application software that controls every aspect of the test. This software allows the operator to program all stages of the test and provides real-time comparisons of tests results with published, predicted values. All standard test procedures are pre-programmed, and the CATS software is flexible and powerful enough to allow for custom test procedures. The GCTS Dynamic Modulus software automatically generates the full Master Curve and all other related test results after completion of the test, which can be exported as a Microsoft™ Excel spreadsheet.







Test Results Exported to Microsoft™ Excel

The GCTS software has simplified the operation of our instruments by allowing the user to directly program test calculated parameters in the units of interest (stress, strain, etc.) based on the specimen dimensions. These parameters are calculated in real-time and are available for display and/or control in either Metric or English units. In addition, the stress and strain amplitudes, as well as phase shift, are calculated at the end of each cycle. These parameters are calculated using sophisticated regression analysis that includes all data points within each cycle.

The GCTS CATS application software for Dynamic Modulus testing includes automated test control and report generation according to AASHTO T 342, ASTM D3497, and EN 12697-25 specifications, as well as user-definable test procedures. This program includes a function solver to obtain the Master Curve from test data according to AASHTO or Witczak functions.

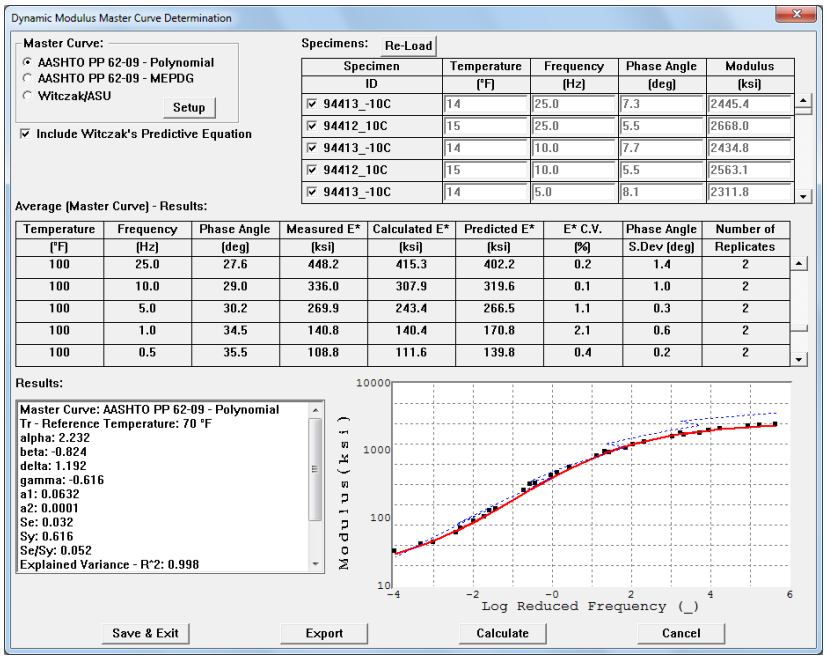
Behind the GCTS CATS software is the SCON-3000 digital servo controller that can be configured with up to 23 universal sensor inputs and outputs and has a 24 bit resolution for very high precision measurement and control. All signal conditioning, as well as high speed data acquisition and control functions are performed by the GCTS SCON unit and controlled by the user through the GCTS CATS software.

The fully Integrated Digital Servo Controller has an embedded microprocessor capable of performing all test functions even if the Windows™ computer is turned off. It provides automatic dynamic control mode switching between any connected transducer and calculated parameter. This controller also conditions all transducers used in the ADM-100 system. This digital controller is capable of updating the control loop at up to 6 kHz as is required for high frequency dynamic tests. The GCTS controller has several adaptive compensation techniques to improve the control precision without user intervention. Adaptive control allows the system to precisely match the desired cyclic stress amplitudes throughout the tests.

The ADM-100 can also be customized to allow for the use of regular LVDT holders in place of the non-contact sensors. It can also be customized to allow for indirect tension, direct tension, resilient modulus, and beam fatigue tests by removing the rotating table. Both low and high strength calibration specimens are available for each test. Low strength specimens are ideal for training new operators, as these will not damage the system if an error occurs. The high strength specimens are ideal for system calibration and verification.

The GCTS GPF-100 Automatic Positioning Fixture was designed for easy and accurate positioning of the reference points for the optical micrometers on the cylindrical asphalt specimens used in Dynamic Modulus tests. With the GPF-100 and the specially designed holding pins the need for labor intensive effort is eliminated and the preparation time is reduced to a fraction of the time required otherwise.

Automatic Positioning Fixture



Dynamic Modulus (E*) Test Software

GCTS TESTING SYSTEMS

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