Overlay Test Guide

Cracking Performance Test

TxDOT, Materials and Tests Division – Flexible Pavements Section

Introduction

This document provides guidance and tips for hot-mix asphalt (HMA) mixtures that go through performance testing using the Overlay Test (OT). This document is designed to complement, not replace, the governing test procedure outlined in Tex-248-F. The information provided serves as additional tips and best practices not covered in the test procedure, to be used alongside sound engineering judgment and local expertise in the sampling, preparation, and testing processes with the OT. The document is organized into six sections, as follows:

1. Overlay Plates and Bolts,
2. Sample Preparation,
3. Cutting Recommendations,
4. Gluing Recommendations,
5. Testing Recommendations,
6. Troubleshooting.

The first section is an overview of the testing plates and bolts utilized for the OT. This section offers comprehensive guidance on the selection of plates and bolts for testing, including a detailed explanation of the reasoning behind the choice of these components. This section considered several factors in the adoption of new plates and bolts, including torque specifications, the weight applied to samples, the moments experienced by previous plates, potential shifting issues, and variations in bolt diameter.

The second section is a sample preparation guide for flexible pavements. It offers recommendations on best practices for sample preparation and guidance on optimal procedures for performance evaluation using the OT. This section underscores the critical importance of adhering to Tex-222-F, Sampling Bituminous Mixtures, as improper sampling can lead to extended oven exposure, which may adversely affect the rutting and cracking performance of the mixtures. It provides comprehensive guidance on sample preparation, including sample logging, material splitting, trial evaluations, and mold compaction.

The third and fourth sections provide detailed recommendations for cutting and gluing samples for use with the OT. These sections offer practical guidance on preparing samples to ensure accurate and reliable performance testing. The third section specifically focuses on cutting techniques, while the fourth section addresses best practices for gluing samples, including materials and methods to achieve optimal adhesion and sample integrity. Recommendations are supported by visual aids and step-by-step instructions to assist in proper sample preparation. Additional notes and tips are included to address common challenges and to ensure adherence to best practices.

The fifth section provides comprehensive testing recommendations for the OT, focusing on each of the test inputs and outputs. This section details the optimal procedures for conducting tests and ensuring consistency in testing practices. It includes guidance on setting up the OT, removing tested samples from the device, backing up data, and troubleshooting common issues to maximize the reliability and accuracy of the performance evaluations.

The final section addresses troubleshooting techniques to ensure the repeatability and reliability of OT samples. It emphasizes the importance of proper sample preparation, consistent testing procedures, and accurate data handling to maintain high standards in performance evaluations.

Following these guidelines ensures that samples are prepared correctly for OT testing, maintaining the accuracy and reliability of the results. While this guide focuses on these practical aspects, it does not cover the selection of mixtures, binders, or aggregate properties, as these are typically addressed by existing TxDOT guidelines and policies. For additional assistance with binder and aggregate selection, or if further support is needed, contact your district pavement engineer, district construction engineer, laboratory personnel, or the Flexible Pavements Section of the Materials and Tests Division.

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1. Overlay Test Plates and Bolts

This section highlights the critical importance of using the correct plate dimensions and bolt specifications for accurate OT performance. The dimensions of the plates, as detailed in Figure 1.1, are essential for ensuring reliable test results. Deviations from these specified dimensions can lead to unreliable outcomes due to potential shifts in plate alignment, which affect the test readings.

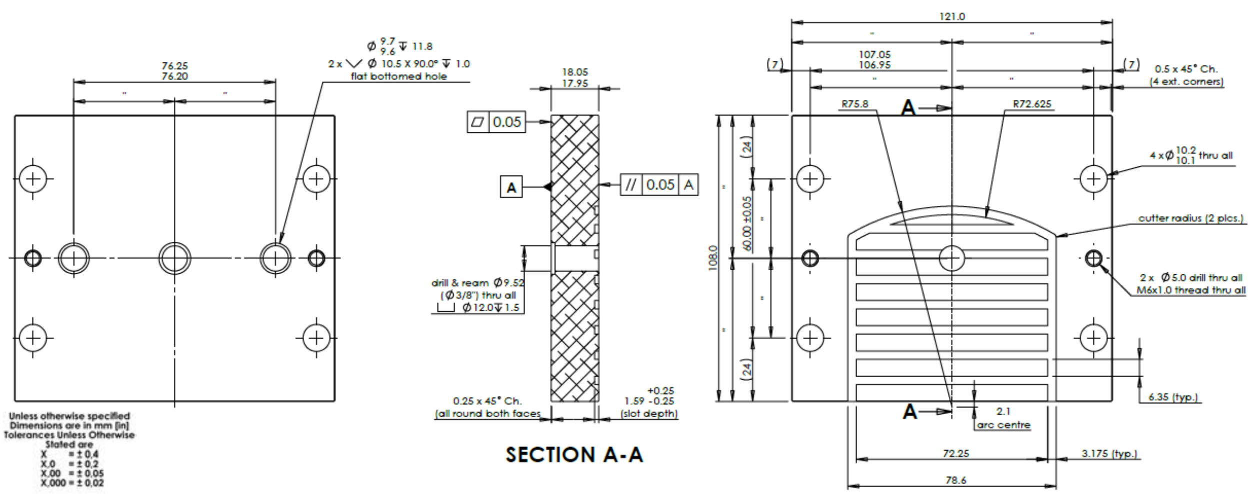

Figure 1.1 –Schematic of Plates

It is crucial that the hole diameter of the plates and the diameter of the bolts does not differ by more than 0.008 inches from the specified measurements. Figure 1.2 illustrates a schematic of the bolt, any deviation beyond this tolerance can result in a misalignment of the plates during testing, leading to erroneous data. Similarly, the bolt diameter is integral to maintaining plate stability.

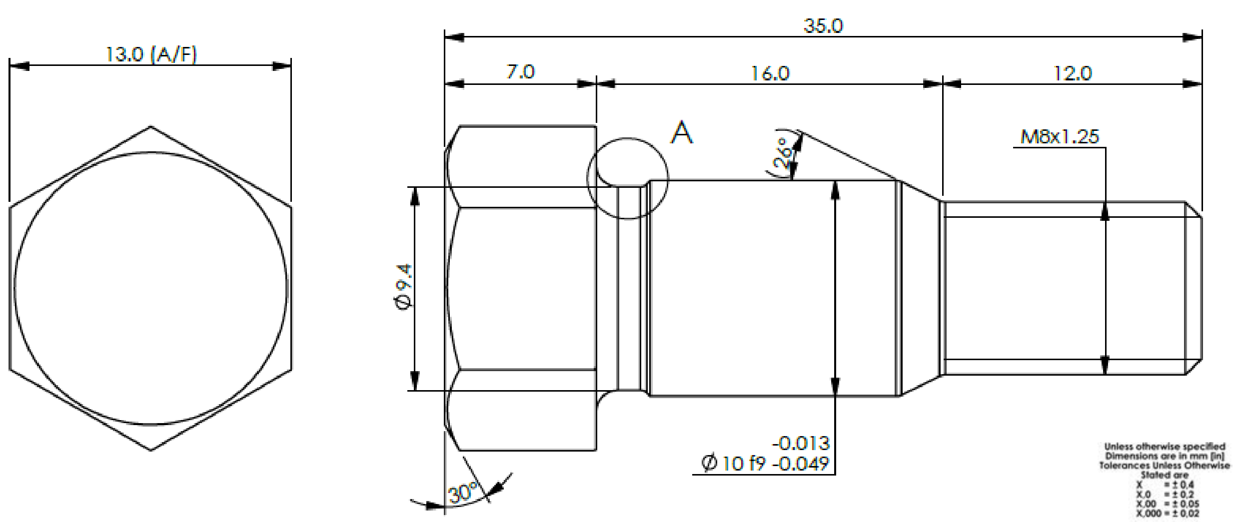

Figure 1.2 –Schematic of Bolts

The updated test procedure requires a torque setting of 25 ft-lb for the bolts. To accommodate this change, the bolts have been designed to endure the new torque specifications. Modifications have been made to the shaft of the bolts—the point most susceptible to wear—to ensure durability and consistent performance over time (see Figure 1.3).

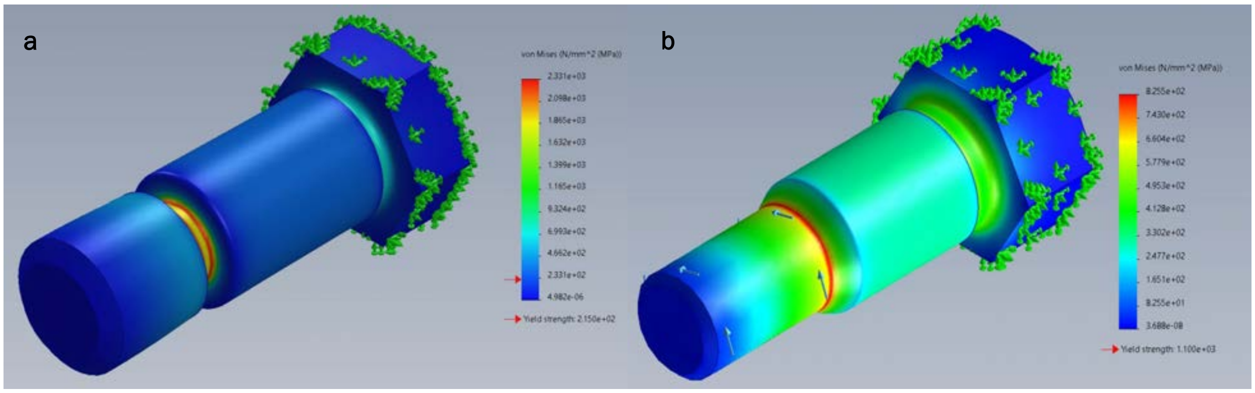

Figure 1.3 – Finite Element Model of Bolts (a) Old Bolts (b) New Bolts

Figure 1.3 depicts a von Mises stress index, which shows the resultant stresses developing within the bolts in relation to their yield strength at test conditions. Yield strength is an inherent property of the material and defines the point at which the bolt undergoes plastic deformation, leading to failure if the von Mises stress exceeds this limit. Beyond the material's properties, the geometry of the bolt plays a vital role in stress distribution. Variations in design, such as changes in shank diameter or thread profile, can significantly affect how stresses are concentrated. For instance, areas with sharp changes in geometry, like thread undercuts, tend to experience higher stress concentrations, making the bolt's shape a critical factor in preventing failure under load. Together, both the material's strength and the bolt's design determine its ability to withstand applied stresses without succumbing to deformation or failure.

The old bolts were made from 304 stainless steel, which has a yield strength of approximately 215 MPa, and had a thread undercut that created a high-stress region. This led to von Mises stresses that exceeded the material's yield strength, making the bolts vulnerable to shearing. To solve this, the bolts were redesigned with a tapered shank, distributing stress more evenly across the grip length, which reduced the von Mises stress from 2331 MPa to 825 MPa. Additionally, the steel grade was upgraded to Grade 12.9 high tensile steel, which has a much higher yield strength of around 1100 MPa, significantly improving the bolts' ability to withstand higher forces without plastic deformation occurring.

These improvements to both the design and material are essential to ensure the integrity of the Overlays performance and to eliminate variability related to the testing equipment, allowing for a more reliable assessment of the material itself.

2. Sample Preparation

Proper sample preparation is crucial for accurate performance testing with the OT. HMA samples must be transported and stored in paper bags or cardboard boxes, with a maximum thickness of 3 inches, as per Tex-222-F. Adherence to Tex-222-F guidelines is essential to prevent issues such as prolonged short-term aging, uneven aging across the mix, and non-compliance with the required curing duration as specified in Tex-241-F.

For OT testing, approximately 20,000 grams of material is required. This quantity accounts for both trial and triplicate samples, ensuring comprehensive testing. The density of trimmed test specimens must be 93 ± 1%, except for Permeable Friction Course (PFC) mixtures and Crack Attenuating Mix (CAM). Generally, laboratory-molded specimens should typically have a density of 91 ± 1% to meet the 93 ± 1% requirement once trimmed. This guideline is based on typical results; however, adjustments should be made based on prior experience and the specific materials used. Mixture weights for laboratory-molded specimens that meet the density requirement generally fall between 4,200 and 4,500 grams.

Do's:

- Breakdown/split your trial and triplicate samples properly.
- Cure in accordance with Tex-241-F.
- Thoroughly blend loose mix to obtain representative samples.
- Conduct tests within 5 days of molding.

Don'ts:

- Do not increase molding temperature to expedite the breakdown of samples.
- Do not split your mix into sample thickness greater than 3 inches when curing.
- Do not allow binder or RAP to condition simultaneously with aggregate material for laboratory-molded lab-compacted specimens.
- Refrain from using the same binder for multiple samples after it has cooled, as this can increase oxidation.

3. Cutting Recommendations

The preparation of OT samples is a critical user-dependent process where precision and attention to detail are crucial. Among the various stages, cutting the samples requires the most time and accuracy.

For optimal results, use a wet saw with a blade diameter ranging from 10 to 16 inches. It's essential to consider the blade diameter carefully, as it impacts the blade thickness and the dimensions of the trimmed section. Larger blade sizes can be used with caution, as larger blades may warp in or out of the sample, potentially causing uneven cutting. Figure 3.1 illustrates a recommended table saw equipped with a sliding table, which allows for stable sample fixation at one end while facilitating a smooth cutting process.

Figure 3.1 – Sample Cutting Saw Table

Selecting a blade with a diameter sufficient to span the entire length of the sample being cut is crucial, as it reduces the need to shift or rotate the sample during the cutting process, which can compromise precision. Achieving consistent, high-quality cuts is largely a matter of practice; with time, cutting samples will become more intuitive and manageable.

While there are multiple methods for cutting OT samples, the key is ensuring that the final product adheres to the required dimensional tolerances, specifically a height of 1.5 inches and a width of 3 inches (see Figure 3.2). Discard the top and bottom portions of the samples, and focus testing on the middle section only. When guiding the sample through the saw, apply a constant force to ensure a clean and accurate cut.

Figure 3.2 – Overview of Cutting Process

Density verification is another step to ensure compliance with the OT test procedure. Begin by confirming that the water bath temperature is within the specified tolerance range. Verify density in accordance with [Tex-207-F](Tex-207-F), Part I. Immediately after density verification, proceed to dry the samples to a constant weight. To achieve constant weight, samples can be dried either in an oven or using a vacuum drying device. When using a drying device, it is highly recommended to check the sample after each complete dry cycle to avoid overheating and potential sample breakage.

Do's:

- Account for blade thickness as part of your cut and use a cutting template (if available).
- Ensure adequate water flow is maintained during cutting to keep the blade cool and reduce damage.
- Wear proper PPE, including an apron, slip-resistant boots, earmuffs, and safety glasses.
- Clean out the water from the saw on a weekly basis to prevent build-up.
- Clean the cutting table and surrounding area before, during, and after cutting.
- Replace table saw wheels and blades regularly, as needed, to ensure smooth and accurate cuts.
- Use scrap material to verify cuts prior to cutting actual samples to ensure precision.

Don'ts:

- Do not apply excess force or rush the cutting process, as this can lead to inaccuracies and compromised results.
- Avoid cutting samples without first checking that they are within the specified dimensional tolerances.

4. Gluing Recommendations

The success of the OT heavily relies on the gluing process. Proper adhesive selection, application, and curing are vital for ensuring an effective bond. Each of these steps plays a crucial role in ensuring that the OT performs effectively under its intended conditions. This section offers a thorough overview of best practices to optimize OT results, encompassing three key phases: preparation, application, and post-application.

When setting up your workspace for the gluing process, it's crucial to have the right tools readily available. Essential tools for the OT gluing process include a small spatula, spacer, a fine-tip marker, epoxy, petroleum jelly, ruler, and a 5-lb weight. The success of the adhesive bond largely depends on the proper cleaning of the gluing surfaces, which include both assembly and testing plates. Start by thoroughly cleaning these surfaces to eliminate contaminants such as dust, grease, or residual epoxy from previous tests. Use an oven at about 310°F to assist in this cleaning process, complemented by a bristle brush and a small flathead tool to ensure that all contaminants are removed from the plate grooves. It is essential to ensure that the surfaces are completely dry and at room temperature before applying the epoxy. Choose an epoxy that aligns with the specifications outlined in Tex-248-F.

Start by placing the assembly block on a clean, level surface. Secure the testing plates with a 4-mm spacer positioned between them. While the exact positioning of the plates is not critical at this stage, ensure they are bolted down firmly enough to prevent shifting or trapping the spacer, which will be removed later. Next, inspect the surface of the OT sample to identify the area with the least imperfections, as this will facilitate a stronger bond. Using a ruler, measure and mark a vertical line down the center of the OT sample. Apply a thin layer of petroleum jelly along this marked line, then place a 4-mm paper strip over the jelly. The spacer, petroleum jelly, and paper strip are critical, as they will be the focal points for initial cracking during testing. When preparing the epoxy, ensure precision in achieving a uniform mixture. A milky or cloudy appearance in the mixed epoxy indicates proper blending. Prepare approximately 16 grams of epoxy for each sample, applying 8 grams to each half separated by the paper strip. The key is to avoid applying epoxy to the area covered by the paper strip and petroleum jelly. Apply the epoxy evenly to avoid gaps, extending it up to but not over the paper strip to ensure a solid bond without weak spots. Once the epoxy is applied, immediately flip the OT sample onto the testing plate. Gently press the sample with your fingers to help initiate and distribute the bond. Subsequently, place a 5-lb weight on top to ensure firm contact and optimal adhesion. Check for any excess epoxy that may have oozed out from the sides. Use a straight razor to carefully trim away this excess epoxy while it is still soft, ensuring a clean finish and preventing interference with the testing process. Lastly, ensure you remove the spacer bar and paper strip before allowing the epoxy to cure.

Once the epoxy has been applied, allow it to cure undisturbed for a full 24 hours. During this curing period, it is crucial to maintain a stable environment, avoiding drastic fluctuations in temperature or humidity levels, to ensure bonding of the sample to the plates. Following this, transfer the triplicate samples to an environmental chamber for conditioning. This step should be carried out for a minimum of 1 hour to ensure that the samples reach uniform temperature. Proper conditioning is essential to avoid variability and ensure consistent performance across all samples. Finally, proceed with testing each sample using the OT. This systematic approach ensures that the samples are in optimal condition and that the test results will be accurate and reliable.

Do's:

- Apply approximately 16 grams of epoxy to each sample, with 8 grams applied to each half.
- Remove any excess epoxy from around the sample immediately after application to prevent interference with testing.
- Apply gentle pressure when setting the sample onto the assembly mold to ensure proper adhesion.
- Remove the paper strip and spacer to avoid any residue affecting the test.
- Ensure that the epoxy is spread up to the paper strip to create a strong and consistent bond.

Don'ts:

- Do not apply excess force when placing the sample, as this may cause the epoxy to escape from between the plate and the sample, compromising the bond.
- Avoid leaving the paper strip on the sample during testing, as it may affect the accuracy of results.
- Do not proceed with testing without pre-conditioning the samples or allowing adequate time for the epoxy to cure, as this may lead to inconsistent results or abnormal behavior.

5. Testing Recommendations

This section provides guidance on configuring the testing inputs and outputs for the OT test. Proper documentation of each sample is crucial for identifying and tracking test parameters, which ensures accurate and reliable results. After a minimum of 1 hour of curing, during which the sample should be left undisturbed, the testing sample is transferred to the OT. The following interfaces will prompt the necessary settings and inputs for the OT test:

Initial Input Interface (see Figure 5.1):

1. **File Name:** This field should display the date of testing. If it is not showing the correct date, adjust this setting by navigating to Settings → Time & Date Settings.
2. **Sample ID:** Enter the material sample ID here (e.g., F915). This uniquely identifies the sample being tested.
3. **Replicate Number:** Input the replicate number (e.g., A, B, C or 1, 2, 3) to differentiate between replicated from each test.
4. **Sample Description:** Provide a detailed description of the sample, including the mix type and binder type. Accurate documentation of these details is crucial for reproducibility and analysis.
5. **Next Arrow:** Proceed to the next interface by selecting the “Next” arrow.

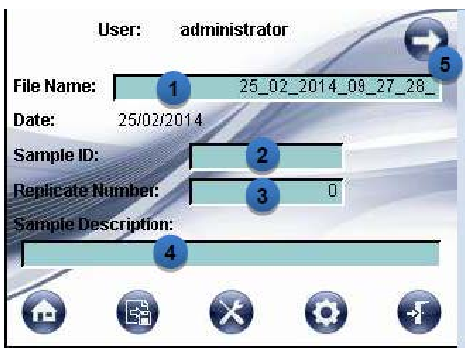

Figure 5.1 – Initial Input Interface

Second Input Interface (see Figure 5.2):

1. **Sitting Time:** This field should display the time the sample was left untouched after cutting. Proper documentation of sitting time is important for consistency in testing conditions.
2. **Density:** Enter the density of the sample here. This is a key parameter for the OT test and must be accurately recorded.
3. **Failure Limit:** Set this to display a load drop of 93%. This value indicates the threshold at which the sample is considered to have failed.
4. **Cycle Limit:** Input the number of cycles (1000 cycles) to which the sample will be subjected during testing.
5. **Next Arrow:** Move to the next interface by selecting the “Next” arrow.
6. **Back Arrow:** Return to the previous interface if needed by selecting the “Back” arrow.

Figure 5.2 – Second Input Interface

Final Input Interface (see Figure 5.3):

1. **Temperature**: Display the OT testing temperature (25°C). Ensure that this temperature is consistently maintained throughout the testing process.
2. **Cycle Time**: Enter the time in seconds for each testing cycle (10 seconds). This setting controls the duration of each individual test cycle.
3. **Sample Interval**: Set the sample interval to 0.10 seconds. This defines the frequency at which measurements are recorded during testing.
4. **Displacement**: Enter the testing displacement (0.635 mm). This is the amount of movement applied to the sample during each test cycle.
5. **Save to**: Choose the storage medium for saving test data—either a flash card (CF) or USB drive. While it is recommended to use a USB drive and back up data bi-weekly, users may opt to use a CF card. However, be aware that CF cards tend to fill up quickly, and there is a risk of losing data if the card reaches capacity. Ensure regular monitoring and transfer of data to prevent data loss.
6. **Completion of Input**: Confirm and finalize all input settings before beginning the test.

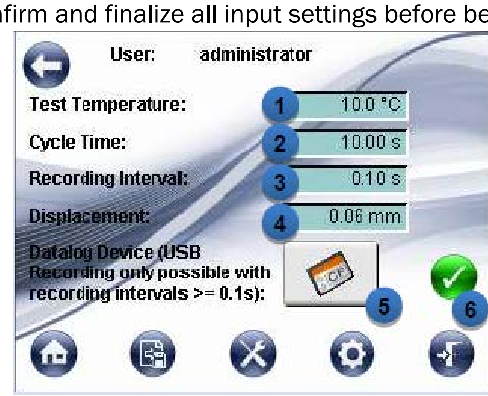

Figure 5.3 – Final Input Interface

Once all the inputs have been entered into the machine, ensure you follow the on-screen instructions for each sample precisely. It is essential to reset the machine when prompted to avoid any issues during testing. When positioning the Linear Variable Differential Transformers (LVDT) into the testing region, aim to have both values as close to identical as possible for accurate measurements. For sample placement in the OT, follow the sequence illustrated in Figure 5.4 and bolt down the sample with a torque of 25 ft-lb. Proper bolting ensures secure sample placement and consistency in test results. It is important to observe the first few cycles of the test, as these early results can be indicative of how long the sample will last overall.

Figure 5.4 – Recommended Bolt Tightening Pattern

The output screen displays key performance metrics for each test sample. Accurate interpretation of these values is essential for evaluating the sample's performance. The OT is programmed to stop if either a 93% load drop is achieved or if the sample reaches 1000 cycles, whichever comes first. Typically, an OT sample that completes the full 1000 cycles will undergo approximately 4 hours of testing.

Output Scheen Interface (see Figure 5.5):

1. **Cycles**: This field displays the total number of cycles the sample achieved before failure. Ensure this value aligns with the test parameters and is within the expected range for the sample type.
2. **Cracks**: This field should be updated to display "1" after the completion of each test, indicating the occurrence of a single crack or failure event. This helps in tracking the test outcome for each sample.
3. **Load Drop**: Displays the percentage of load drop experienced by the sample. This value is critical for assessing the sample's durability and performance under test conditions.
4. **Critical Fracture Energy (CFE)**: Shows the CFE value, which quantifies the extent of crack formation or failure in the sample. This metric provides insight into the sample's resistance to cracking.
5. **Crack Progression Rate (CPR)**: Displays the CPR value, representing the rate at which cracks propagate through the sample. This helps evaluate how quickly damage spreads during testing.
6. **Crack Resistance Index (CRI)**: Indicates the CRI value, a measure of the sample's overall resistance to cracking. This index is essential for determining the sample's suitability for its intended application.

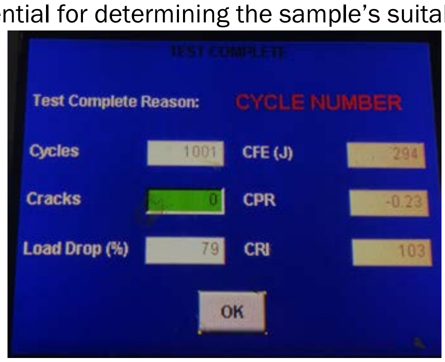

Figure 5.5 – Test Completion Output Screen

6. Troubleshooting

This section is designed to offer immediate support and guidance for common issues encountered with the OT. However, it is highly advisable to consult the manufacturer before taking any action. Doing so can help prevent additional complications that may lead to further delays and ensure that any troubleshooting is aligned with the manufacturer's recommendations. Always prioritize professional guidance to safeguard the integrity and functionality of the unit.

Table 1. OT Troubleshooting Reference

Error	Possible Reason	Action
Corrupted data.	Faulty data port.	Utilize a multi-USB port with an external power supply to decrease the risk of damaging the port.
Unit is having issues cooling.	The OT may be low on refrigerant levels.	Ensure the OT is turned off when not in use to prevent temperature-related issues.
The load cell does not open as it is detecting a load.	Residue, indirect pressure applied to the load cell, or obstruction at the back of the load cell.	Check that the load cell base components are free of residue, unwanted weight, and any objects at the back that may obstruct its operation.
Unable to detect sample.	Placed the sample in the machine prior to resetting the machine.	Remove the sample, reset the machine, and then follow on-screen instructions.

NOTE: Always consult the manufacturer before performing any actions on the unit to ensure proper procedures are followed and to maintain warranty coverage.