REI ENGINEERS

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Roof Failure Investigation
Lee County Sheriff Core II Building
2505 Ortiz Avenue, Ft. Myers, Florida

Client: Lee County Government, FL

Representative: **Mr. Dan Weis**

Consultants: REI Engineers

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Scott Hinesley, PE, RRC
President

SCOTT HINESLEY LICENSE No. 57937 STATE OF FLORIDA PROFESSIONAL ENGINEER

Scott Hinesley

Digitally signed by Scott Hinesley
DN: cn=Scott Hinesley, c=US, o=REI Engineers, email=shinesley@reiengineers.com
Reason: I hereby certify that I, Scott Hinesley (FSPE License No. 57937) did place my seal on this document (titled 12F-54 Core II Rpt. Ltr Consisting of 29 pages on September 7, 2012
Date: 2012.09.07 13:30:44 -04'00'

Date: September 7, 2012

Roof Failure Investigation
Lee County Sheriff's Core II Building

TABLE OF CONTENTS

I. AUTHORIZATION

This report presents the findings of a roof assessment conducted at the Lee County Sheriff Core II Building at the Ortiz Detention Center in Fort Myers, FL. The assessment was authorized by Lee County through a Lee County Service Provider Agreement, dated April 19, 2012.

II. PURPOSE

The purpose of the assessment is to determine the cause of the failure of the roofing system on the referenced facility through:

- Review of available documents and information provided by Lee County Facilities Management, including; architectural plans and details, roof installation and maintenance records, warranty information, and other such documents regarding the roof systems.
- Review of reasonably accessible exposed surfaces of the system to locate specific problems and evaluate the overall needs of the roof areas in question.
- Analysis of core samples taken in accordance with ASTM D 2829 *Standard Practice for Sampling and Analysis of Built-up Roofs*.

III. SCOPE

The scope of the work performed is outlined in REI Proposal No. 12F-08P dated February 17, 2012.

IV. WARRANTY NOTICE

The findings and recommendations submitted for the subject roof are based upon available information furnished by participating personnel, as well as investigative test procedures. The observations and recommendations presented in this report are time dependent and conditions will change. REI warrants these findings have been presented after being prepared in accordance with generally accepted practices of RCI, Inc., The Institute for Roofing, Waterproofing and Building Envelope Professionals. No other warranty is expressed or implied. This report has been prepared for the exclusive use of Lee County and its agents.

V. EXECUTIVE SUMMARY

Based on our review of the roofing system at this facility, it is our opinion that the deficiencies present (damaged/split insulation and roofing membrane and membrane blisters) are the result of improper asphalt temperatures at the time of application. It is further our opinion that these conditions could result in premature failure of the system including possible blow-off. We are aware that the roof system manufacturer and the original installing contractor have subsequently implemented securement methods in an effort to increase the uplift resistance of the roofing system. We believe this work will provide additional uplift resistance at the perimeters and corners of the facility, however, the field of the roof may still be susceptible to future damage/displacement due to inadequately attached insulation.

VI. DESCRIPTION AND BACKGROUND

The roof system on the 30,000 s.f. Lee County Sheriff Core II Building was installed by Crowther Roofing of Fort Myers, FL in 2008. The system is composed of a structural concrete deck (primed), 3" polyisocyanurate insulation, ½" perlite cover board, 2 plies of Type VI fiberglass felt and a granule surfaced modified bitumen cap sheet. All components were installed in hot asphalt. The roofing system was manufactured and warranted by Johns Manville. Shortly after completion of the roof system installation, the Owner observed numerous blisters throughout the surface of the membrane. Blisters reportedly ranged in size from a few square inches to several square feet. Although the blisters occurred throughout the surface area, they appeared to be more prevalent along the side laps of the cap sheet.

During a routine 2011 rooftop visit by Lee County personnel, a large split in the roofing membrane was observed in the southeast corner of the facility. This split did not appear to be precipitated by any unusual weather event or other extreme phenomena. The split extended through all layers of insulation and created a height differential between adjacent membrane surfaces. A similar but less extreme occurrence reportedly occurred along the western edge of the facility some time earlier.

REI Engineers visited the site during daytime hours on April 26, 2012 to begin the assessment. REI was represented by Mr. Scott Hinesley, PE, RRC and Mr. Anthony Ruggiero, RRO. The weather at the time of the site visit was sunny with temperatures ranging from 78-86 degrees F. Representatives of Lee County, Crowther Roofing and Johns Manville were present during the site visit. A brief history and an initial tour of the facility were provided by Mr. Dan Weis and Mr. Jim Taylor with Lee County.

VII. INITIAL VISIT PHOTOGRAPHS

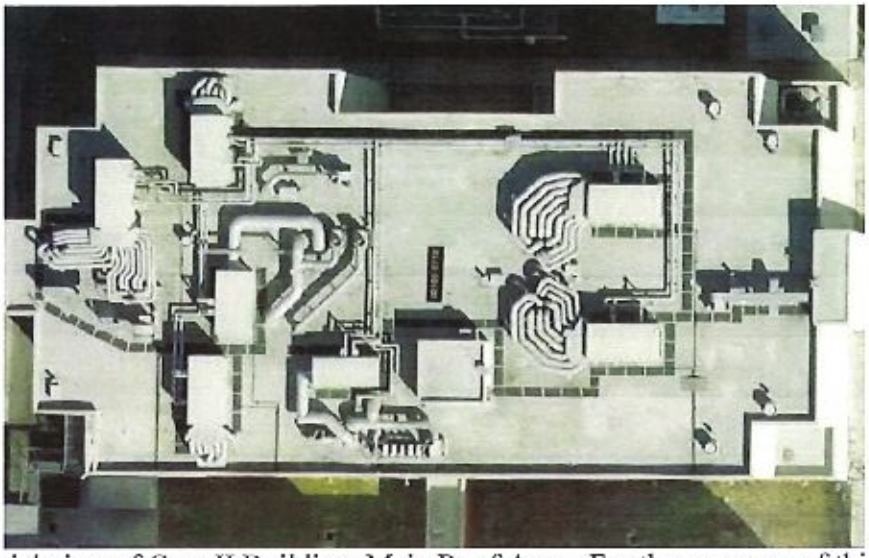


Photo 1 – Aerial view of Core II Building, Main Roof Area. For the purposes of this report, the right edge of the photograph faces south.

Photo 2 – Overview of area of displaced insulation resulting in roof membrane damage. Additionally, note the formation of blisters illustrated in red. These blisters are widespread throughout the entire roofing system.

Photo 3 – View of cap sheet peeled away at location of damage observed in Photo 2. Note the voids present (highlighted by arrows) between the fiberglass felts and the cap sheet. These voids contain air which expands and contracts with temperature changes resulting in the formation and growth of blisters.

Photo 4 – View of fiberglass felts being peeled off the perlite coverboard. Note the split in the underlying isocyanurate insulation (indicated by arrow).

Photo 5 – Moisture meter probes confirmed the presence of high moisture content within the perlite coverboard. We believe this moisture contamination occurred as a result of the membrane split illustrated in the previous photographs.

Photo 6 – Close-up view of the split isocyanurate insulation and perlite coverboard.

Photo 7 – Upon lifting of the isocyanurate insulation, we observed the bottom facer to be in tact with no evidence of adhered asphalt. This observation is significant because the absence of asphalt on this facer indicates a lack of adhesion to the substrate. Also note the moisture present on the facer. As previously indicated, we believe this moisture contamination is a result of the membrane split.

Photo 8 – Additional view of undamaged isocyanurate facer due to inadequate asphalt adhesion.

Photo 9 – View of typical blisters throughout the roof system.

Photo 10 – Close up view of membrane blister

Photo 11 – Test cuts taken across the blister reveal the failure plane between the cap sheet and the upper fiberglass ply. This condition is consistent at all locations cut. Membrane samples were collected, labeled and submitted for laboratory analysis (results of analysis included at the end of this report).

Photo 12 – Due to the inadequate adhesion observed on the southeast corner of the building (Photos 2 through 7), test cuts at blister locations were extended to the deck in an effort to determine the degree of adhesion at these locations. As is evident in this photograph, areas completely void of asphalt were encountered.

Photo 13 – Other test cuts revealed approximately 35% asphalt adhesion on the isocyanurate facer. We did not encounter full adhesion at any test cuts taken during this site visit.

VIII. WIND UPLIFT RESISTANCE TESTING

Although REI Engineers was initially retained to investigate the occurrence and cause of roof membrane blisters and the damaged insulation on the southeast corner of the facility, the observation of partially and non adhered isocyanurate insulation created an additional and immediate concern regarding the ability of the roofing system to withstand the uplift pressures required by the Building Code. Due to this concern, REI Engineers recommended additional field uplift testing be performed to determine the uplift resistance of the roofing system at randomly selected areas.

Uplift testing is generally performed utilizing one of two methods: bonded pull testing or negative pressure chamber (or bubble) testing. Because of the time required to obtain the equipment necessary to conduct the bonded pull testing and because of the immediate availability of the negative pressure chamber, REI recommended negative pressure chamber tests be conducted.

REI returned to the site on April 27 to conduct the negative pressure chamber tests in the presence of representatives of Lee County, Crowther Roofing and Johns Manville. It should be noted that prior to this testing, Mr. Hinesley advised all parties that an apparent "passing" test would not necessarily be indicative of adequate system securement, however, an apparent "failing" test would indicate inadequate system securement (see additional discussion in Part X of this report).

IX. WIND UPLIFT RESISTANCE TESTING PHOTOGRAPHS

Photo 14 – View of negative pressure chamber testing apparatus. The system creates a vacuum inside the chamber which imparts an upward force on the roofing system. In accordance with test standards, deflection of the roofing system is measured and compared to allowable tolerances. Excessive upward deflection observed prior to achieving the required design pressures, indicates inadequate system securement.

Photo 15 – View of test procedure

Photo 16 – Of the 5 negative pressure tests performed, only one test did not achieve an "apparent passing" result. The failure occurred near the location of the damaged roof system in the southeast corner of the facility. A test cut at this location revealed the presence of saturated insulation most likely resulting from the damaged roofing membrane. See the following section for a discussion regarding the "apparent passing" of the remaining tests.

X. WIND UPLIFT RESISTANCE TESTING DISCUSSION

Negative pressure chamber testing is a common and widely accepted standard to determine the uplift resistance of in-place roofing membranes. In some instances, the results of this testing can be significantly influenced by the roofing system components and not necessarily indicative of the true uplift resistance of the system.

As indicated in Section VI of this report, the base layer of roof insulation is composed of a single thickness of 3" isocyanurate. It is our opinion that this thickness of insulation provides enough rigidity to skew the results on the high side. Since the testing was initially recommended due to concerns with the adhesion of the isocyanurate to the concrete deck and since we believe the thickness of the isocyanurate insulation skewed the results, we ruled the tests inconclusive.

XI. DISCUSSION AND CONCLUSION

All components of the roofing system specified and installed on this facility are intended to be fully adhered to the concrete deck substrate with hot asphalt. The asphalt acts as a glue to hold the system in place to withstand the uplift pressures prescribed by the Building Code. A quick search of the roof system approvals on the Miami Dade website result in similar compositions achieving uplift resistance approvals of 305 psf. Although we have been unable to determine the design pressures specified by the Architect and his Structural Engineer for this project, we

believe that field pressures of approximately 85 psf and perimeter pressures of approximately 130 psf would be relatively accurate. Given this information, a roof system installed in accordance with the Miami Dade Notice of Acceptance would be more than adequate to withstand the design pressures associated with this facility.

As previously outlined in this report, our test cuts revealed roof system components that were not adequately adhered to the substrate. In several instances, test cuts revealed no adhesion at all. This lack of adhesion creates a potential for the roofing system to blow off as a result of negative pressures associated with a wind event. Although some insulation boards were determined to be partially adhered, there is no definitive way to correlate the degree of adhesion with an expectation of uplift resistance. Inasmuch, we are unable to provide an opinion as to ability of the roofing system to withstand the design pressures required by the Building Code.

Upon review of the of the roof deck at the locations of the test cores, we determined that a full bed of asphalt was applied at the time of installation. Based on the appearance of this asphalt (glassy surface) and the lack of asphalt stains on the underside facer of the isocyanurate board, it is our opinion that the insulation boards at many locations did not come in contact with the asphalt prior to it cooling. After the asphalt cools, a bond cannot be formed, resulting in the conditions observed.

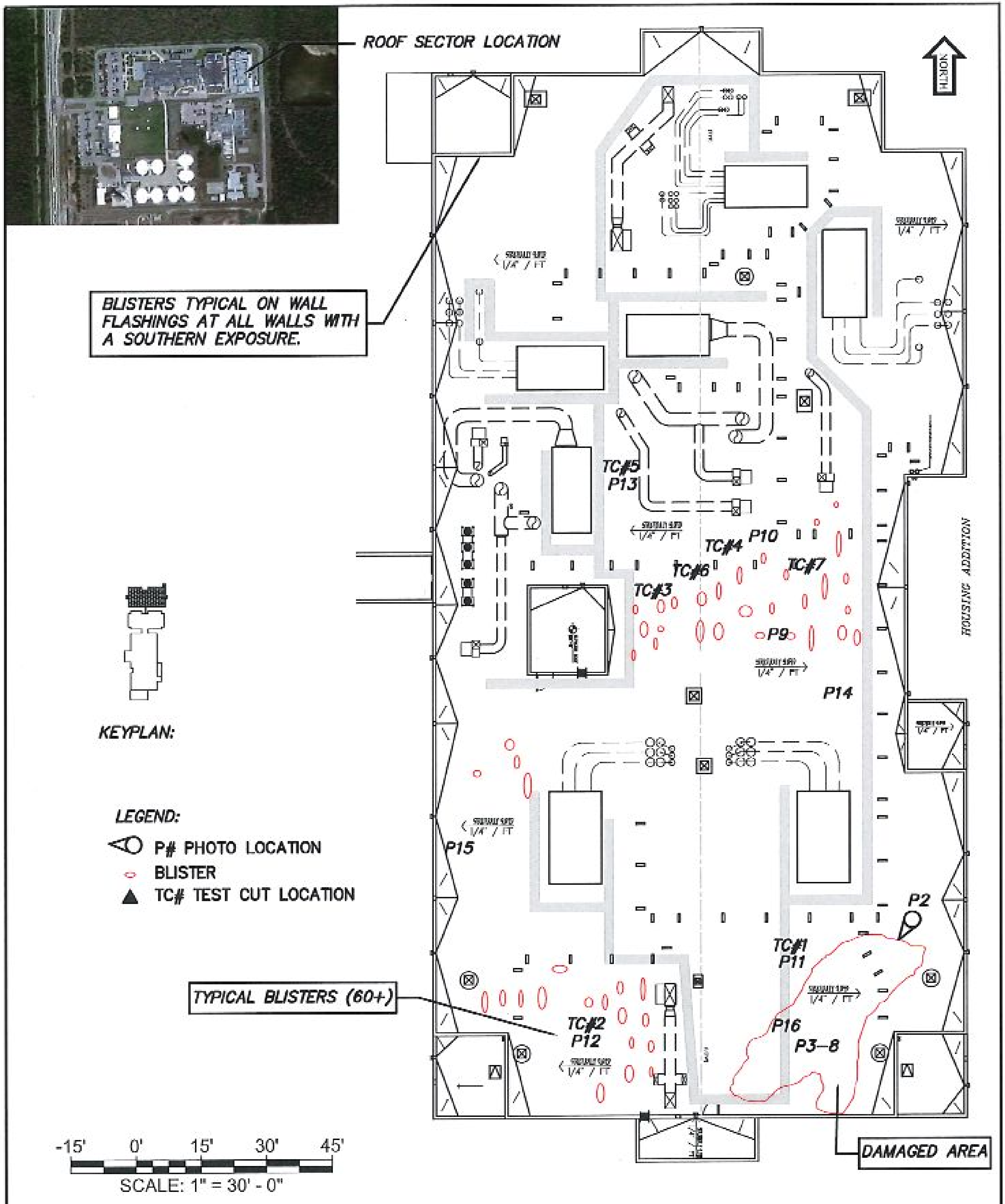
Additionally, it is our opinion that the widespread occurrence of blisters throughout this roofing system is attributable to cold asphalt. According to installation instructions obtained on Johns Manville's website, all layers of roofing membrane are to be adhered with full moppings of hot asphalt applied 25 degrees F above its equiviscous temperature (EVT) at a rate of 23 lbs/sq (1 sq = 100 sq. ft). The EVT is the temperature at which asphalt reaches the proper viscosity for the specified application rate.

A total of 6 test cuts were taken at blister locations throughout the roof and submitted for laboratory analysis. The analysis revealed cap sheet asphalt application rates of: 88 lb/sq, 120 lb/sq, 88 lb/sq, 96 lb/sq, 72 lb/sq and 72 lb/sq. These application rates exceed the rates recommended by Johns Manville and are an indication of asphalt temperatures less than those recommended at the time of installation.

Based on the results of our field investigation, testing and laboratory analysis, it is our opinion that all detrimental conditions observed within this roofing system are a direct result of improper (low) asphalt temperatures at the time of application.

XII. ATTACHMENTS

- ROOF PLAN – a roof plan showing the building outline and the locations of the areas of concern, test cuts, and other specific information is contained herein
- LABORATORY ANALYSIS – the results of the laboratory analysis including void count and asphalt weights is included herein



REI ENGINEERS 24600 S. TAMIAMI TRAIL, SUITE 212-315 BONITA SPRINGS, FL 34134 CHARLOTTE ~ RALEIGH ~ GREENVILLE SC - CHARLESTON FL - FORT MYERS	SCALE: 1" = 30'-0" DATE: 09-07-2012 DRAWN BY: RJL REI PROJECT NO: 12F-54	LEE COUNTY SHERIFF ORTIZ DETENTION CENTER CORE II BUILDING LEE COUNTY FACILITIES MANAGEMENT 1765 HENDERSON AVENUE FT. MYERS, FL 33916
	DETAIL: A1	

CONSTRUCTION MATERIALS TECHNOLOGIES

LABORATORY TEST REPORT

Report for: REI Engineers, Inc.
24600 South Tamiami Trail
Suite 212-315
Bonita Springs, FL 34134

Attention: Tony Ruggiero

Subject: A roof core evaluation was conducted to determine application rate and physical properties of the mopping asphalt used in the roof construction.

Methods: The cores were evaluated as described in ASTM D 2829-07 *Standard Practice for Sampling and Analysis of Existing Built Up Roof Systems.*

Sampling: Thirteen (13) roof cores were received from REI Engineers, Inc. on May 17th, 2012.

Results:

Lee County Forensics

Roof #1/Test Cut #3: 17.5" x 16.75" roof cut composed of oxidized asphalt, glass-reinforced cap sheet and two plies of oxidized asphalt, glass reinforced ply sheet. All plies were fully-bonded in mopping asphalt with no observable voids at the interply. Cap-to-ply application rate of asphalt is estimated at 40 lbs/100 ft^2. Ply-to-ply application rate of asphalt is estimated at 32 lbs/100 ft^2.

Roof #2/Test Cut #6: 18" x 16.25" roof cut composed of oxidized asphalt, glass-reinforced cap sheet and two plies of oxidized asphalt, glass reinforced ply sheet. A lap was observed in the top ply of the roof cut. All plies were fully-bonded in mopping asphalt with no observable voids at the interply. Cap-to-ply application rate of asphalt is estimated at 40 lbs/100 ft^2. Ply-to-ply application rate of asphalt is estimated at 24 lbs/100 ft^2.

Roof #3/Test Cut #9: 19.25" x 18" roof cut composed of oxidized asphalt, glass-reinforced cap sheet and two plies of oxidized asphalt, glass reinforced ply sheet. A lap was observed in the bottom ply of the roof cut. All plies were fully-bonded in mopping asphalt with no observable voids at the interply. Cap-to-ply application rate of asphalt is estimated at 64 lbs/100 ft^2. Ply-to-ply application rate of asphalt is estimated at 32 lbs/100 ft^2.

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Roof #3/Test Cut #10: 23.5" x 14.75" roof cut composed of oxidized asphalt, glass-reinforced cap sheet and two plies of oxidized asphalt, glass reinforced ply sheet. A large void (17" x 7") was observed at the interply of the cap and ply sheets. Cap-to-ply application rate of asphalt is estimated at 72 lbs/100 ft^2. Ply-to-ply application rate of asphalt is estimated at 32 lbs/100 ft^2.

Lee County Gun Range

Roof #1/Test Cut #1: 18.75" x 15" roof cut composed of oxidized asphalt, glass-reinforced cap sheet and two plies of oxidized asphalt, glass reinforced ply sheet. A lap was observed in both the top and bottom plies. All plies were fully-bonded in mopping asphalt with no observable voids at the interply. The cap sheet was observed to be distressed from weathering, resulting in both granule loss and build-up of algae/fungus. Cap-to-ply application rate of asphalt is estimated at 24 lbs/100 ft^2. Ply-to-ply application rate of asphalt is estimated at 24 lbs/100 ft^2.

Roof #1/Test Cut #2: 20.5" x 15.75" roof cut composed of oxidized asphalt, glass-reinforced cap sheet and three plies of oxidized asphalt, glass reinforced ply sheet. A large (10" x 11") void was present at between the bottom two plies. All plies were fully-bonded in mopping asphalt with no observable voids at the interply. Cap-to-ply application rate of asphalt is estimated at 32 lbs/100 ft^2. Top ply-to-mid ply application rate of asphalt is estimated at 20 lbs/100 ft^2. Mid ply-to-bottom ply application rate is estimated at 56 lbs/100 ft^2.

Roof #1/Test Cut #3: 21" x 18.5" roof cut composed of oxidized asphalt, glass-reinforced cap sheet and two plies of oxidized asphalt, glass reinforced ply sheet. A lap was observed in the bottom ply and a T-joint in the top ply. A void (6" x 4") was present at the ply-to-ply interface. Cap-to-ply application rate of asphalt is estimated at 24 lbs/100 ft^2. Ply-to-ply application rate of asphalt is estimated at 32 lbs/100 ft^2.

Ortiz Core 2 Bldg

Test Cut #2: 18" x 11.5" roof cut composed of oxidized asphalt, glass-reinforced cap sheet and one ply of oxidized asphalt, glass reinforced ply sheet. A lap was observed in both the cap and ply sheet. The lap was found to incompletely bonded in the cap sheet. Cap-to-ply application rate of asphalt is estimated at 88 lbs/100 ft^2.

Test Cut #3: 21.75" x 13.5" roof cut composed of oxidized asphalt, glass-reinforced cap sheet with two plies of oxidized asphalt, glass reinforced ply sheet. A lap was observed in the cap sheet. The lap was found to incompletely bonded in the cap sheet. Cap-to-ply application rate of asphalt is estimated at 120 lbs/100 ft^2. Ply-to-ply application rate of asphalt is estimated at 24 lbs/100 ft^2.

Test Cut #4: 16.5" x 13.25" roof cut composed of oxidized asphalt, glass-reinforced cap sheet with two plies of oxidized asphalt, glass reinforced ply sheet. The interplies were observed to be fully bonded. Cap-to-ply application rate of asphalt is estimated at 88 lbs/100 ft^2. Ply-to-ply application rate of asphalt is estimated at 24 lbs/100 ft^2.

Test Cut #5: 18.5" x 18.5" roof cut composed of oxidized asphalt, glass-reinforced cap sheet with two plies of oxidized asphalt, glass reinforced ply sheet. A lap was present in the top ply sheet. The interplies were observed to be fully bonded. Cap-to-ply application rate of asphalt is estimated at 96 lbs/100 ft^2. Ply-to-ply application rate of asphalt is estimated at 24 lbs/100 ft^2.

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Test Cut #6: 41" x 5" roof cut composed of oxidized asphalt, glass-reinforced cap sheet and one ply of oxidized asphalt, glass reinforced ply sheet. A lap was observed in the ply sheet. The cap was found to completely unbonded to the ply sheet. Cap-to-ply application rate of asphalt is estimated at 72 lbs/100 ft^2.

Test Cut #7: 41" x 5" roof cut composed of oxidized asphalt, glass-reinforced cap sheet and one ply of oxidized asphalt, glass reinforced ply sheet. Two laps were observed in the ply sheet. A small void was observed at the cap-to-ply interface. Cap-to-ply application rate of asphalt is estimated at 72 lbs/100 ft^2.

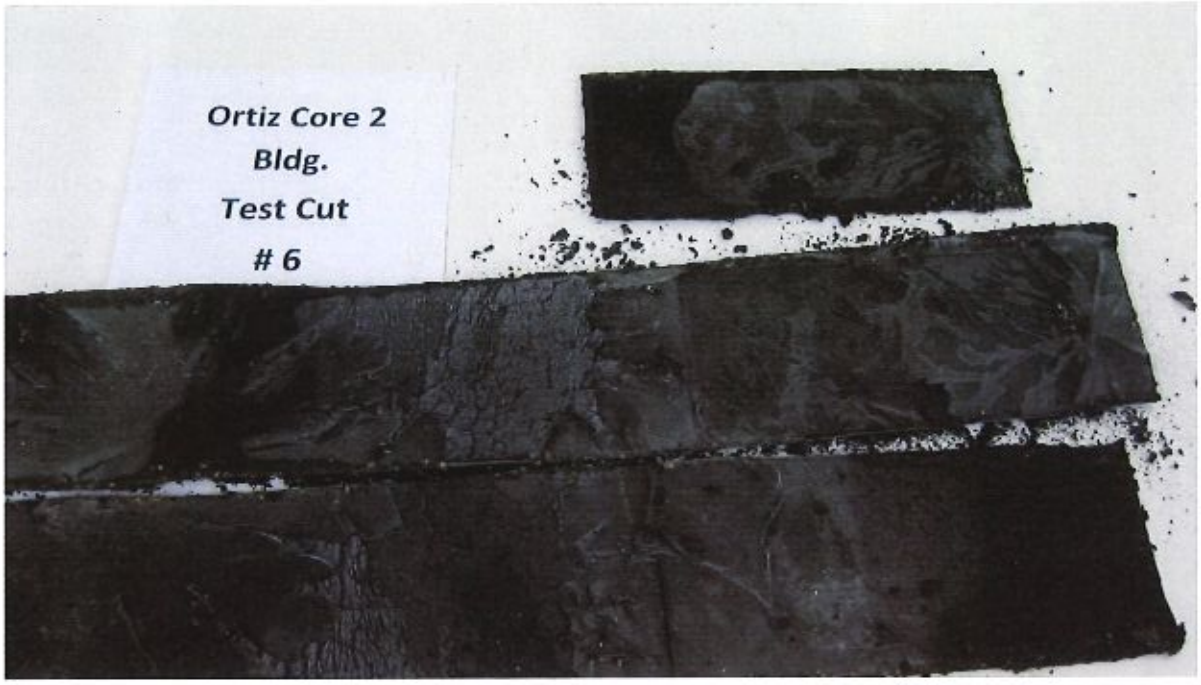
Remarks: Voids were present in several of the roof samples as noted above. The probable cause is attributed to application of the ply or cap sheet outside the EVT range.

Mopping asphalt coverage rates were also noted in several samples outside the typical application range of 20-40 lbs/100 ft^2.

Attestation: It is noted the opinions expressed in this report are based solely on the core samples analyzed by this laboratory.

Signed: _____
Zach Priest, P.E.
Director

Date: June 29, 2012



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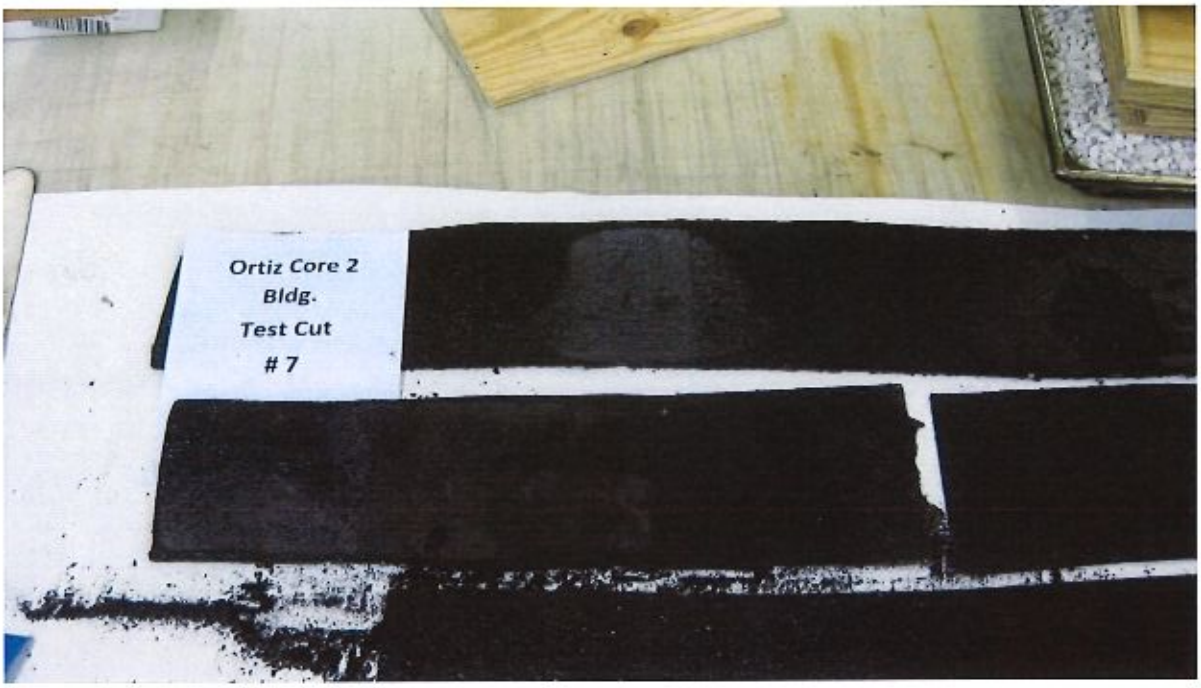

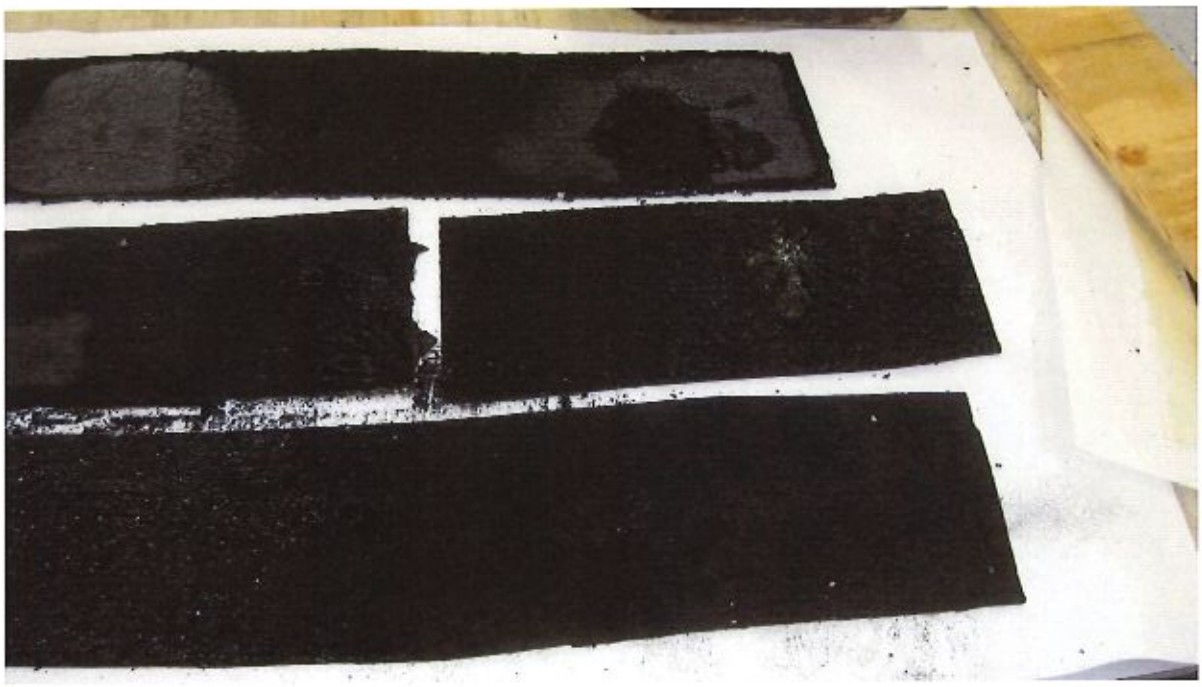

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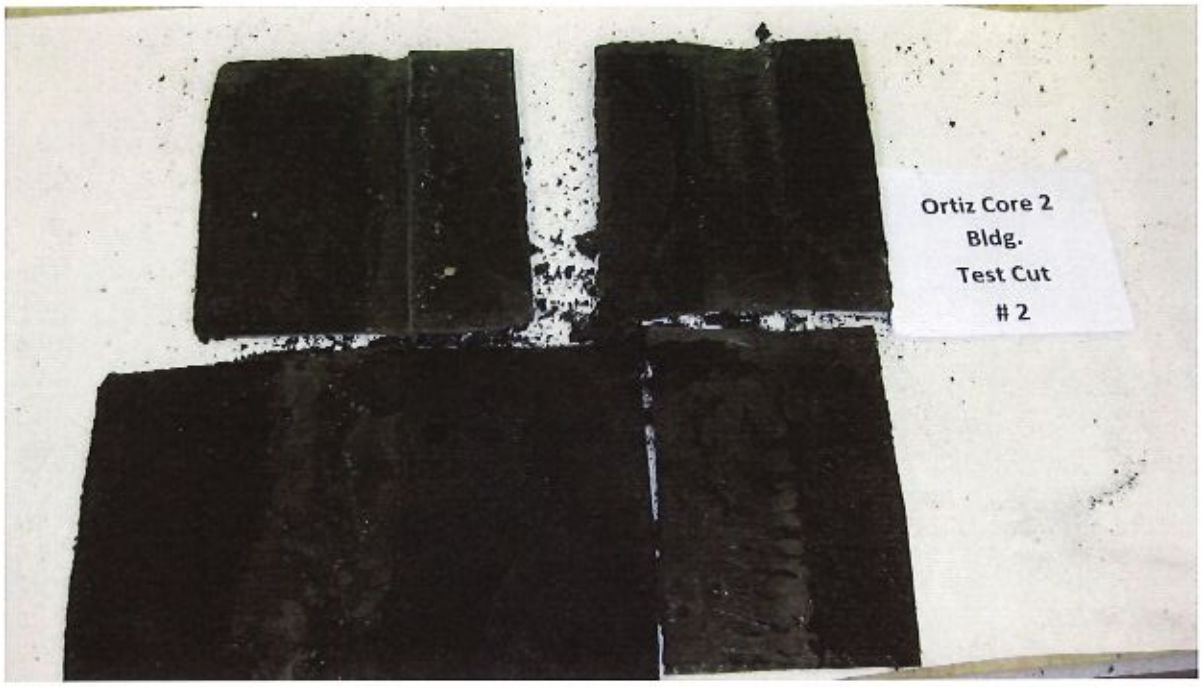

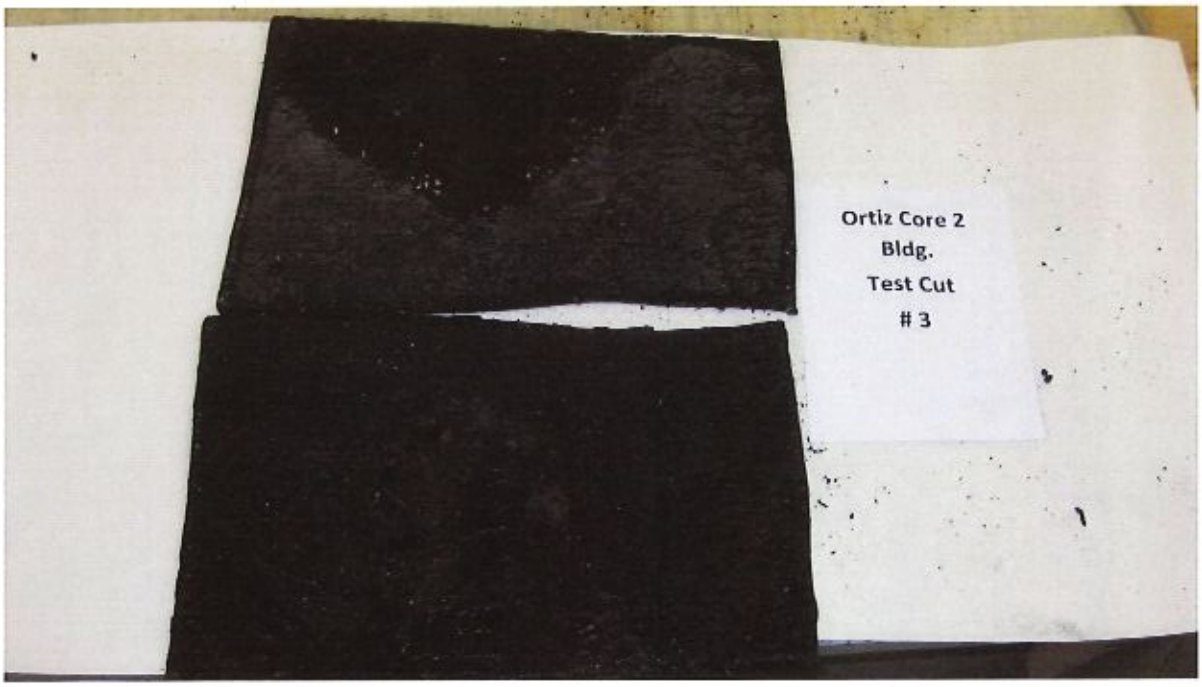

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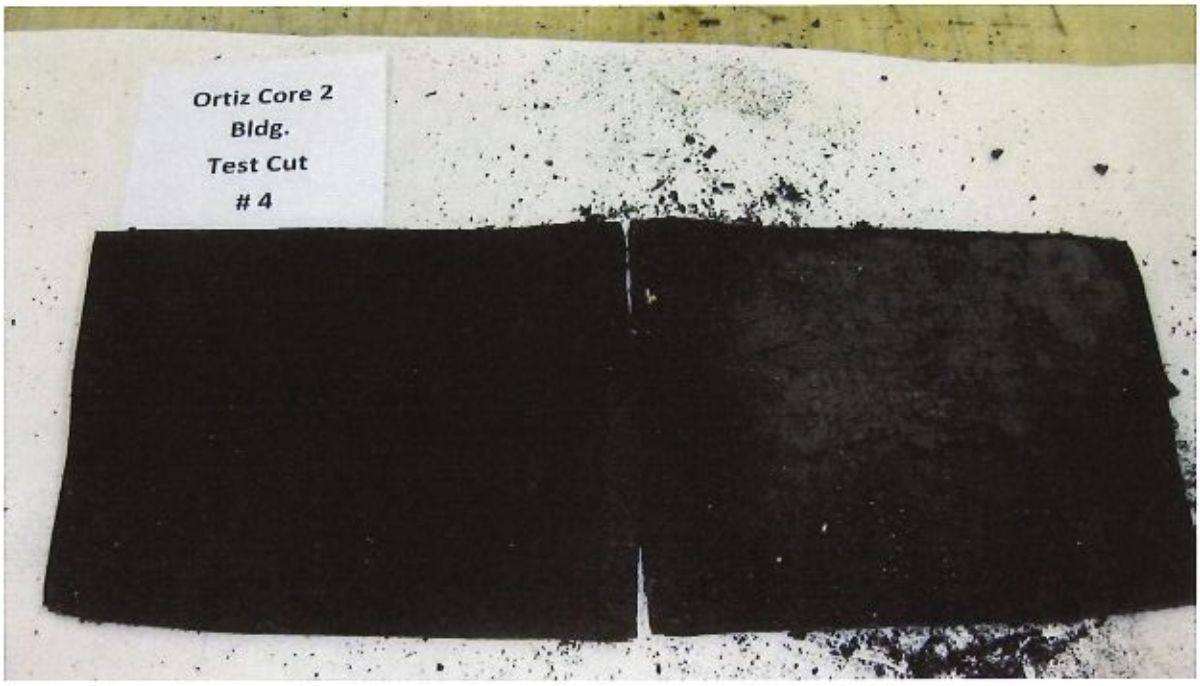

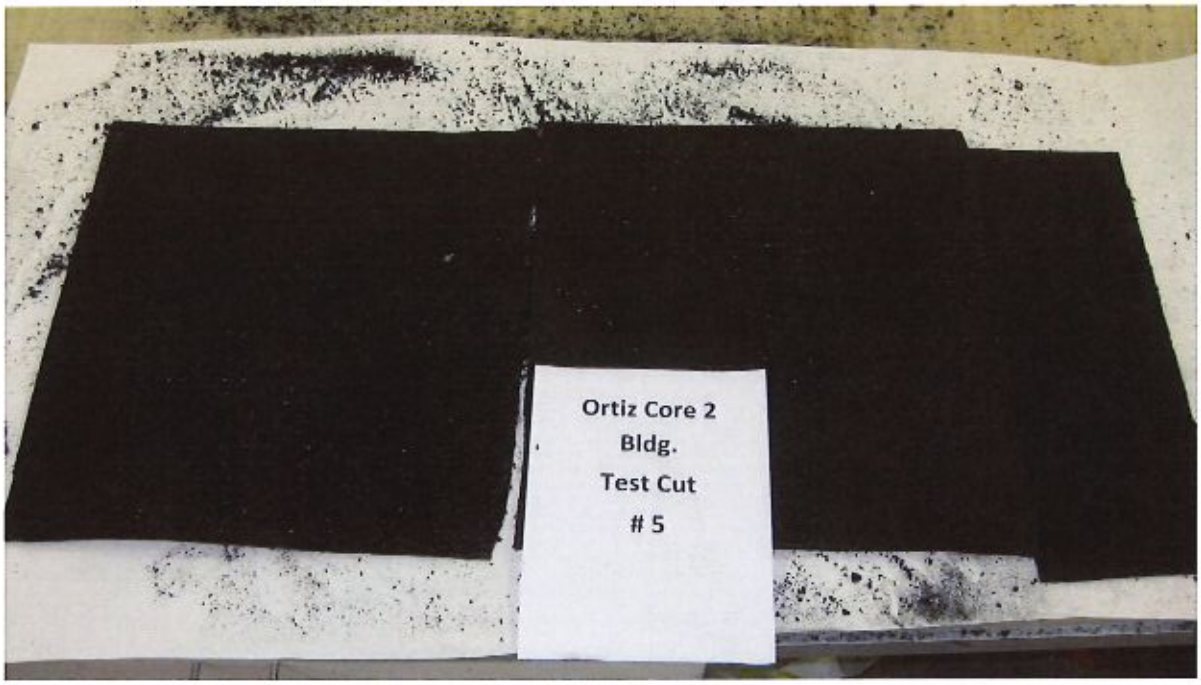

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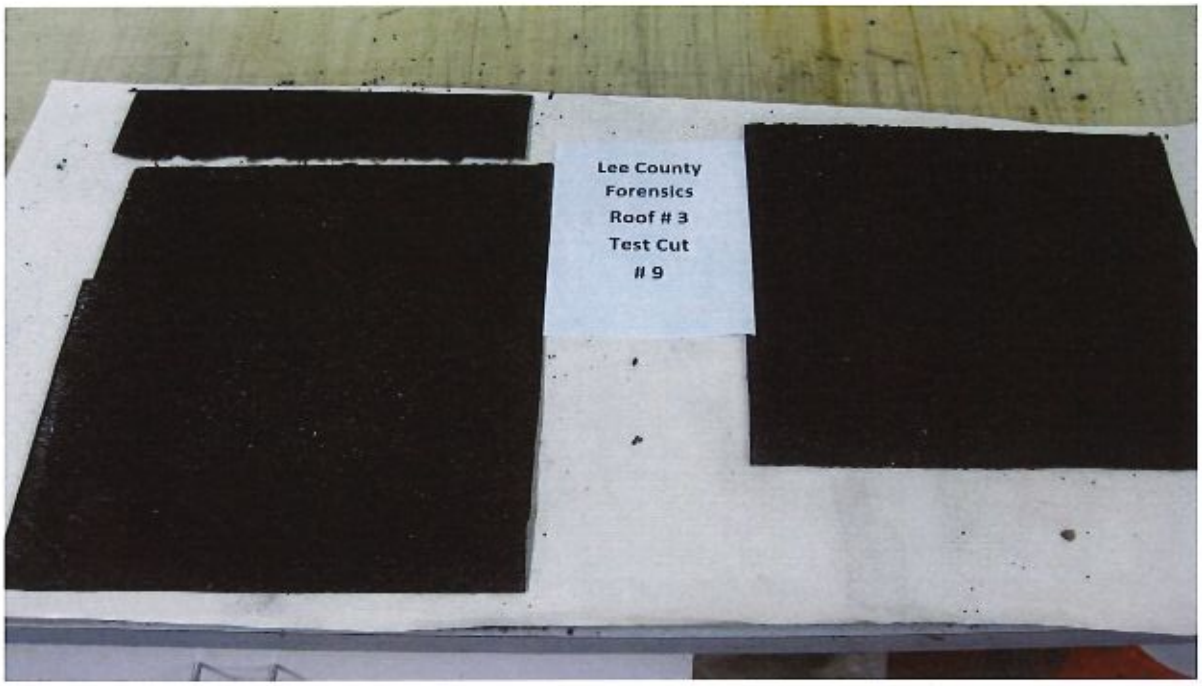

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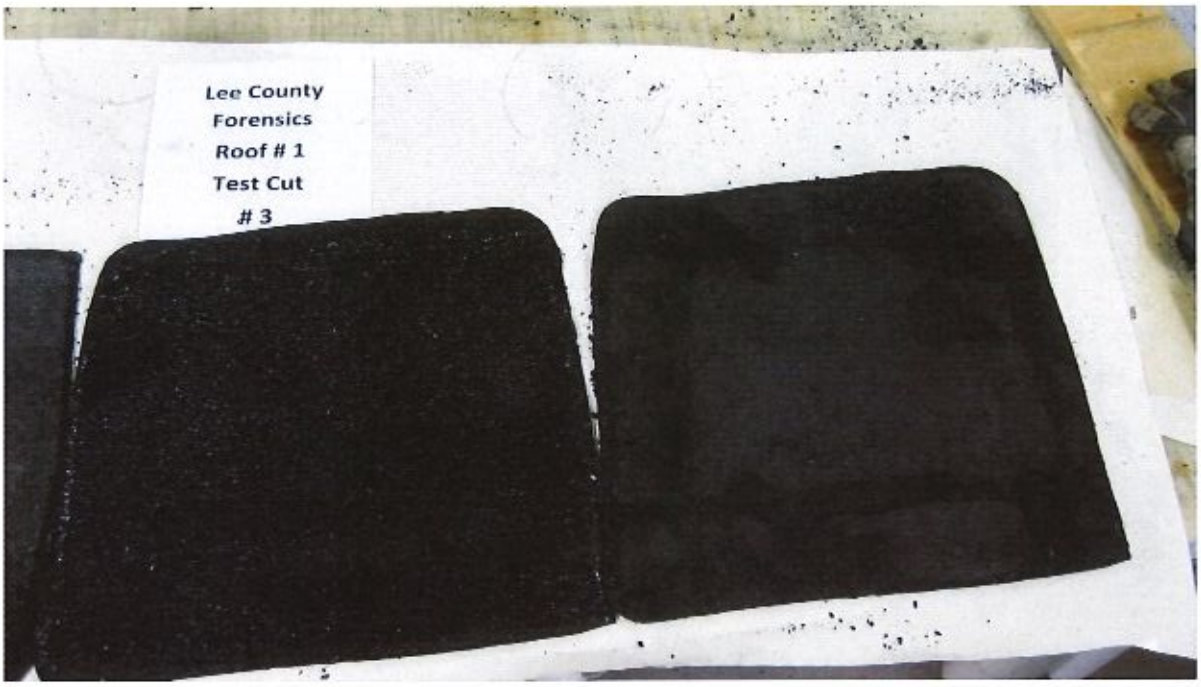

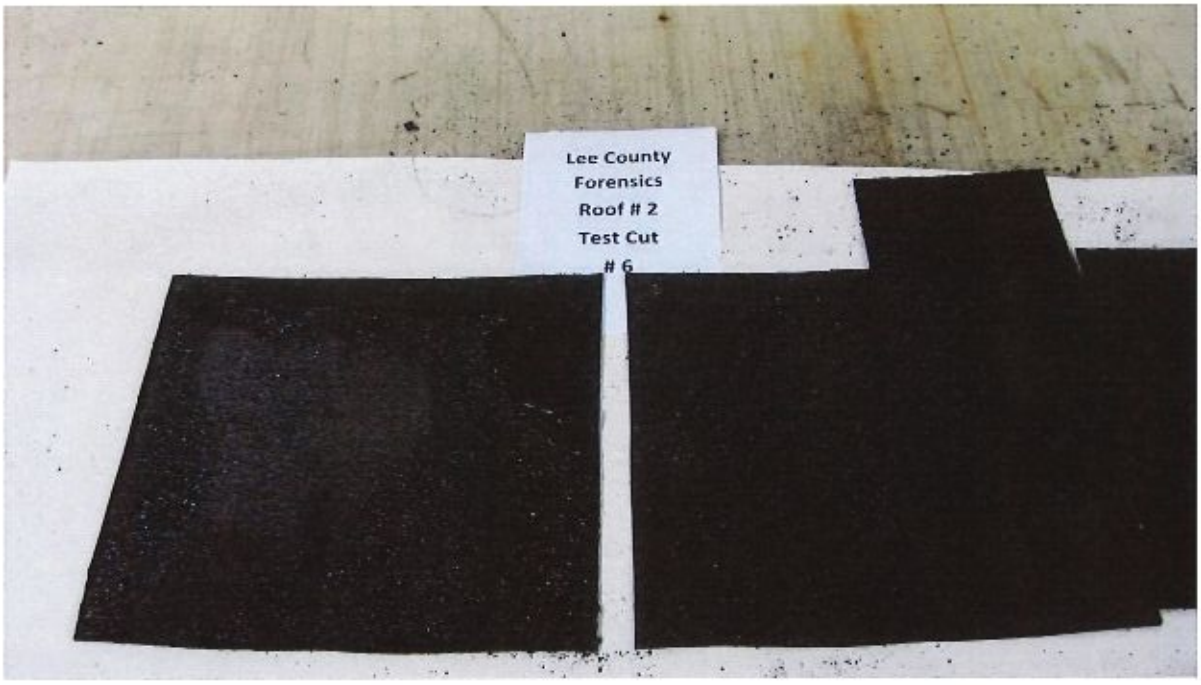

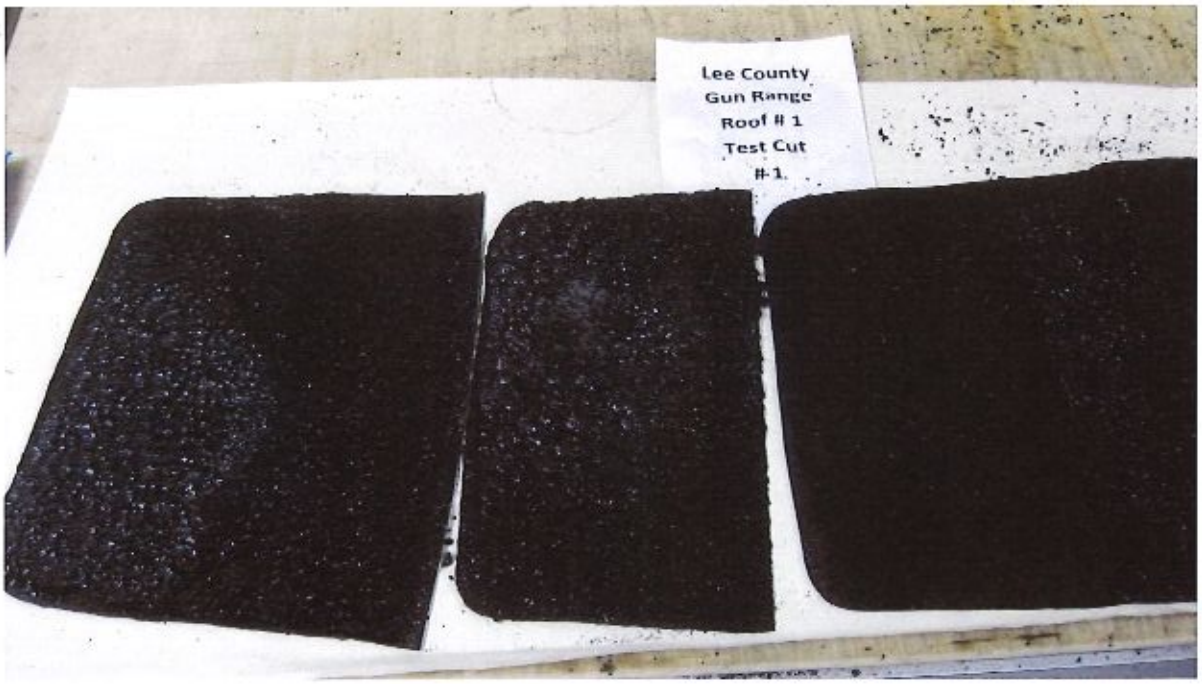

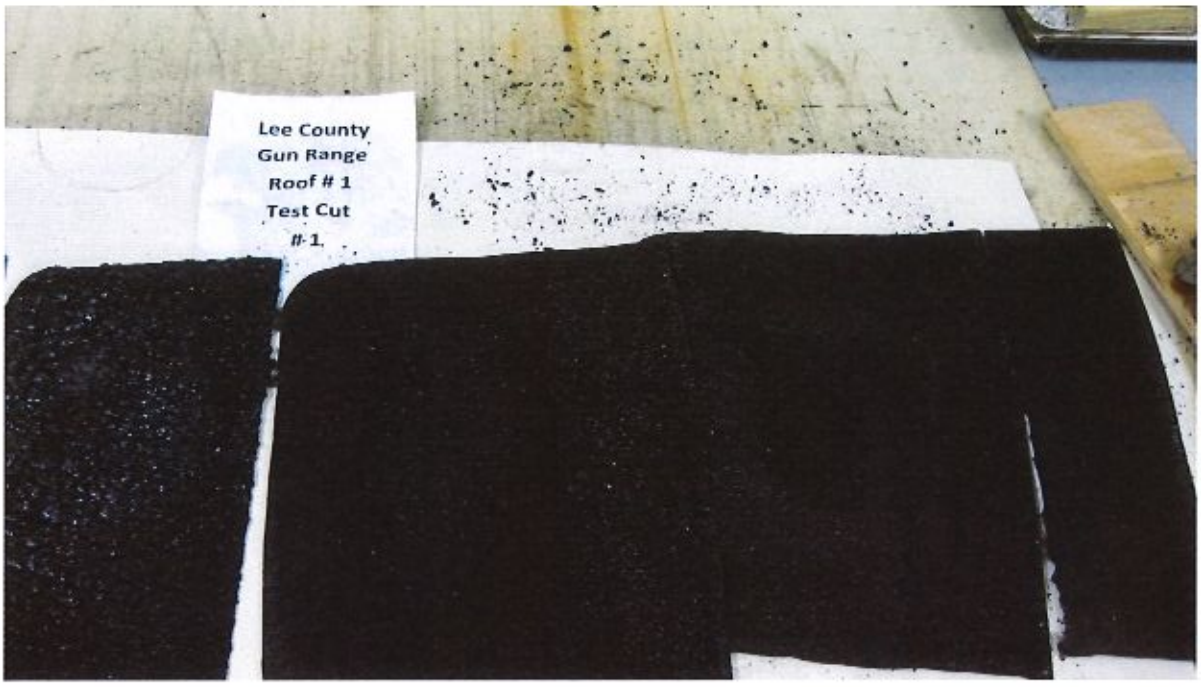

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END OF REPORT

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