Appendix E

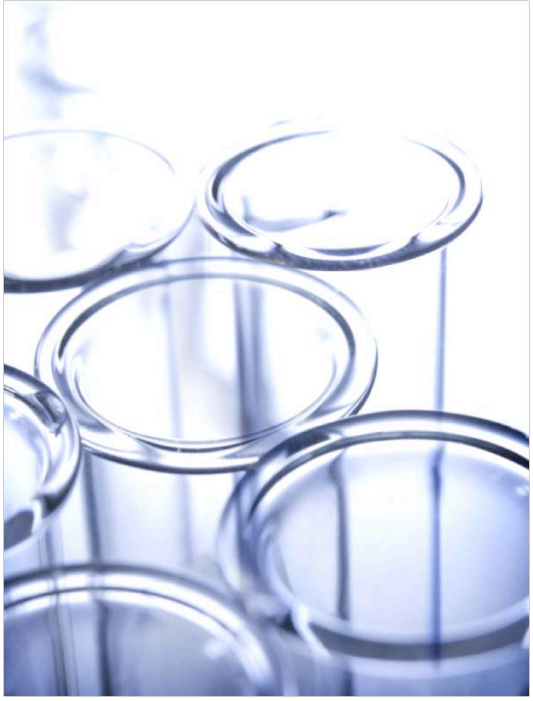
Avomeen Analytical Services Failure Analysis: Concrete and Adhesive Investigation (9/22/2011)

CONFIDENTIAL REPORT FOR:

Board of Equalization Building
450 N. Street, Sacramento, CA

PREPARED FOR:

LaCroix Davis
Lafayette, CA



Prepared By:
Avomeen Analytical Services
6107 Jackson Road
Ann Arbor, MI 48103
Date: October 2, 2011

To:
Ted Ice
LaCroix Davis LLC
3685 Mt. Diablo Blvd., Suite 210
Lafayette, CA 94549
tice@lacroixdavis.com

Submission Date:	August 23, 2011
Report Date:	September 22, 2011

Failure Analysis: Concrete and Adhesive Investigation

Thank you for contacting Avomeen Analytical Services for the failure analysis of tile, adhesive, and concrete samples in the Board of Equalization Building, 450 N. Street, Sacramento, CA. Following are the results, data, and methodology associated with our analysis of the samples.

Results and Executive Summary

1.) pH values for the five samples of concrete tested found variations in concrete pH levels from 10.1-11.2. These pH values seemed to correlate with level of odor and delamination at the original sample locations.
2.) Fourier-Transform Infrared Spectroscopy (FT-IR) analysis found some variation between the peak heights of 'suspect' and 'control' samples. For the adhesive samples, higher IR spectral peak values correlated with greater stickiness and odor. For the concrete samples, we found low correlation between the peak heights of various samples and the characteristics of these samples.
3.) GC/MS analysis could not conclusively determine the chemical composition of the odor since sufficient odorous compounds could not be collected from the samples.
4.) EDXA analysis found that the three major ingredients in the concrete samples were calcium, silicon, and oxygen. The ratio of calcium vs. silicon and oxygen in these samples was higher in the odor samples vs. the non-odor samples. This increased level of calcium in samples could be the cause of higher pH values in the concrete.
5.) Based on the data from the samples tested, we believe that the composition of the concrete is most likely leading to the failure of the adhesive, which then causes the odor issue. Concrete composition and pH values should be monitored during the installation process of any future tiling projects. Concrete with high pH levels could be treated or coated to prevent future degradation of the tile adhesive.

Discussion of Results and Methodology:

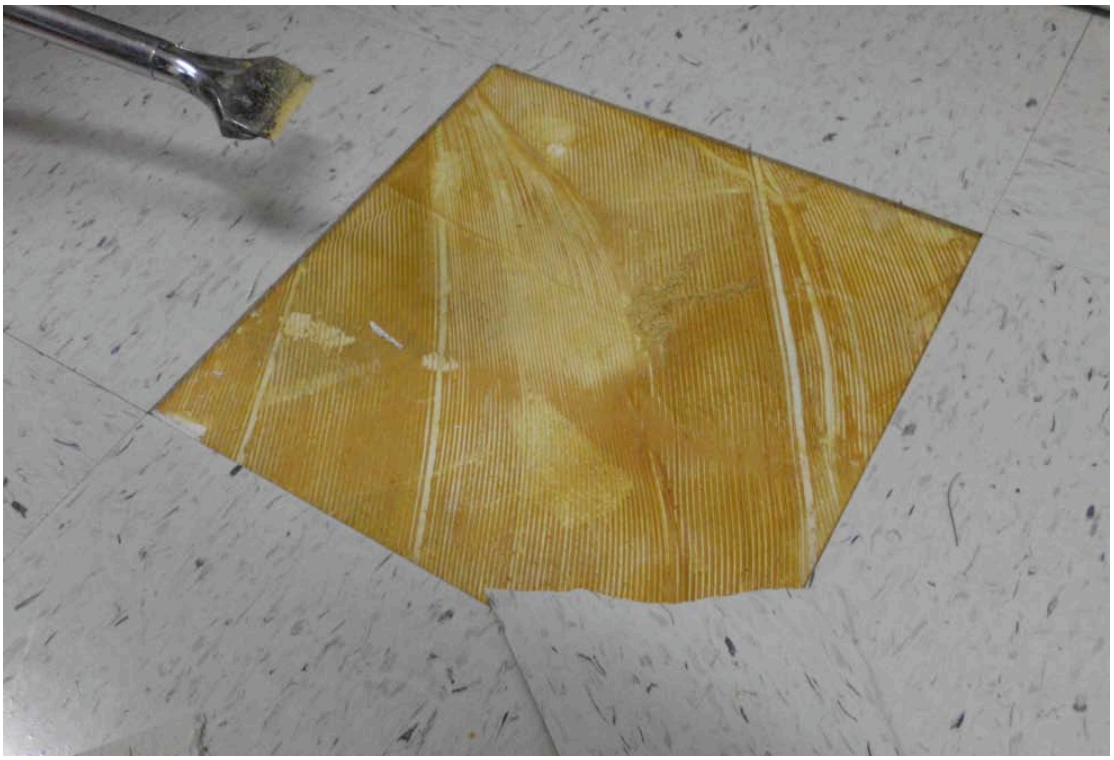
On August 20th, 2011, Avomeen president Neil Thanedar traveled to the site of the failure analysis to inspect the possible causes of the failure, along with supervising the collection of 16 sets of samples, collected from rooms described as 'odor' and 'non-odor' rooms, expected to correlate with 'suspect' and 'control' samples, respectively. Samples were then shipped to Avomeen's laboratory facilities for analysis by FT-IR, GC/MS, EDXA, and pH.

For the purposes of our laboratory testing, Avomeen selected five sets of samples, chosen based on the quality of the samples collected and to represent a wide range of room conditions, including samples with the highest odor and delamination and control samples exhibiting little to no failure (See Table 1).

Documentation of Sample Collection

Room R143: Major tile cracking. Wide tile seams. Uneven surfaces.

Room 5B: Sample of tile experiencing no visible failure (no wide seams or cracking).

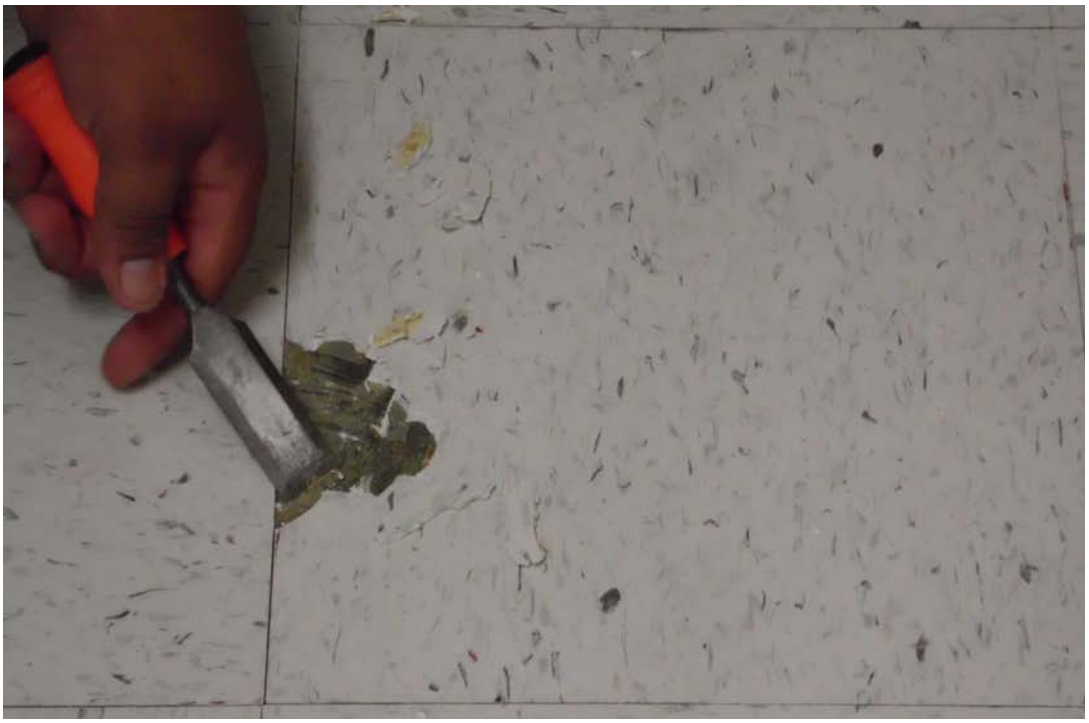


Room 5B: Tile was easily removed. Adhesive was uniform, but sticky.

Room 6B: Adhesive collection process. Tile, adhesive, and concrete were collected.

Room 6B: Tile had sticky, odorous adhesive, despite listing of 6B as non-odor room.

Room 7B: Concrete powder collection mechanism. Surface was scraped clean to remove all traces of adhesive and tile before sampling.

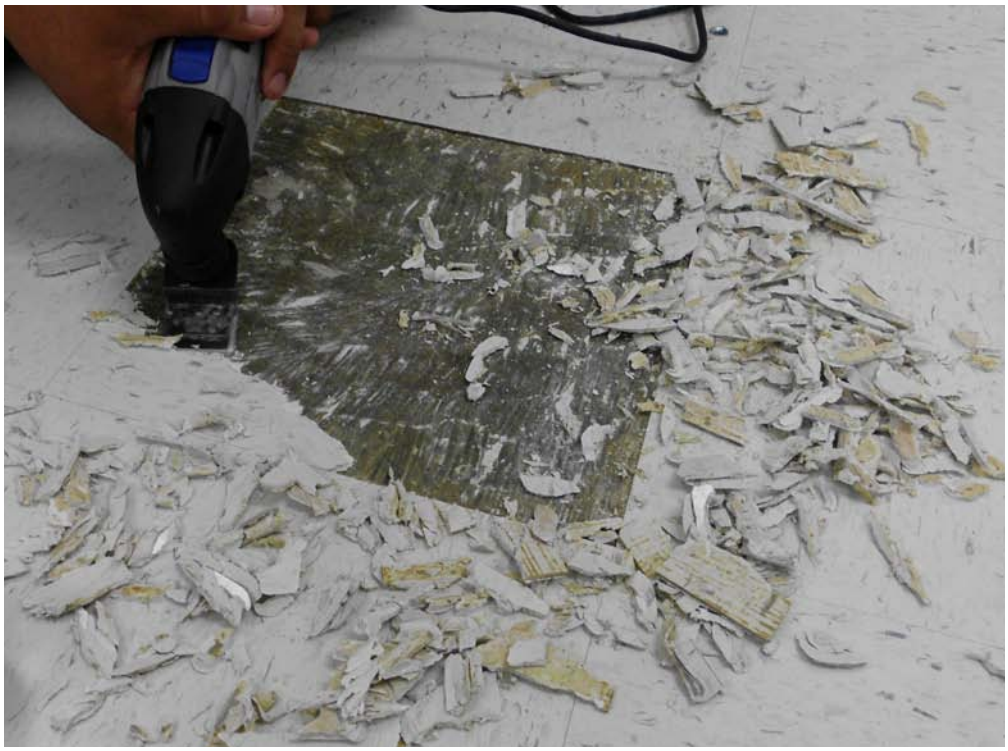


Room 7B: Many tiles with dry adhesive were strongly attached to concrete surface, and were only able to be removed in small chunks of tile.

Room 15B: Mechanized tile removal process used for samples with dry adhesive

Room 10B: Adhesive collection process. Tile, adhesive, and concrete were collected.

Room 19B: Concrete exhibited minor cracking. Unrelated to adhesive failure



Room 17B: Low odor room with dry adhesive. Tile was strongly attached to concrete.

Room 10B: Medium odor room with delamination. Tile was easily removed.

List of Samples Tested by Avomeen

Room #	Sample Description
6B	Labeled a 'Non-Odor' room. Exhibited some odor once tile was removed. Tile adhesive was sticky and tiles had wide seams.
9B	Labeled a 'Non-Odor' room. Samples were most dry, and least odorous, of the whole building. Used as primary control sample.
19B	Labeled an 'Odor' room. Dark staining on edges of tiles. Highly delaminated with a strong odor. Large amounts of adhesive.
2235	Labeled a 'Non-Odor' room. Tile was easily removed in two pieces – heavily delaminated. Odor present once tiles removed. Room had supply air, which could have affected determination of 'Non-Odor'.
23B	Labeled an 'Odor' room. Highly delaminated. Odor present.

Table 1. *Room and sample descriptions collected on August 20th, 2011.*

Fourier-Transform Infrared Spectroscopy (FT-IR) Analysis

FT-IR spectra were obtained for four representative adhesive samples and five representative concrete samples. Figure 1 shows and compares the FT-IR spectra of the "as received" adhesive samples. Figure 2 shows and compares the FT-IR spectra of the "as received" concrete samples. Figure 3 shows the FT-IR spectral comparison of a representative adhesive sample from Room 6B (a 'suspect' room labeled 'Non-Odor') with a FT-IR spectral library search result for chlorinated polyethylene.

For the adhesive samples, we found a distinct difference between the IR peak heights of the 'suspect' adhesive samples in the 800 cm-1 to 1200cm- regions vs. the 'control' adhesive sample (Room 9B), which correlated also correlated with the stickiness of the adhesive samples. Dry adhesive produced lower IR spectral peaks than sticky adhesive in this region. All peak locations and relative peak intensities were similar across all adhesive samples, which indicates that the overall composition of these adhesive samples has low variation.

For the concrete samples, we found low correlation between the peak heights of various samples vs. the descriptions of the samples and collection locations. All peak locations were similar across all concrete samples, which indicates that the overall composition of these concrete samples has low variation. Relative peak intensities varied throughout the experiment. Since concrete composition is largely inorganic, a technique such as EDXA would be more beneficial for comparing chemical composition of these samples.

See page four for the FT-IR spectra described in this section (Figures 1-3)

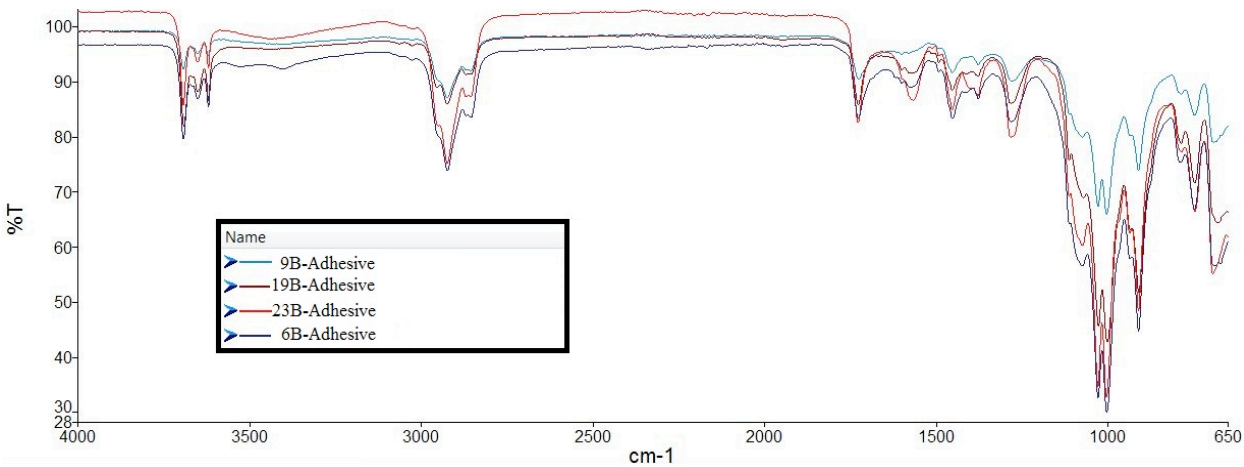


Figure 1. *FT-IR spectrum of four adhesive samples (Rooms 6B, 9B, 19B, 23B) as received*

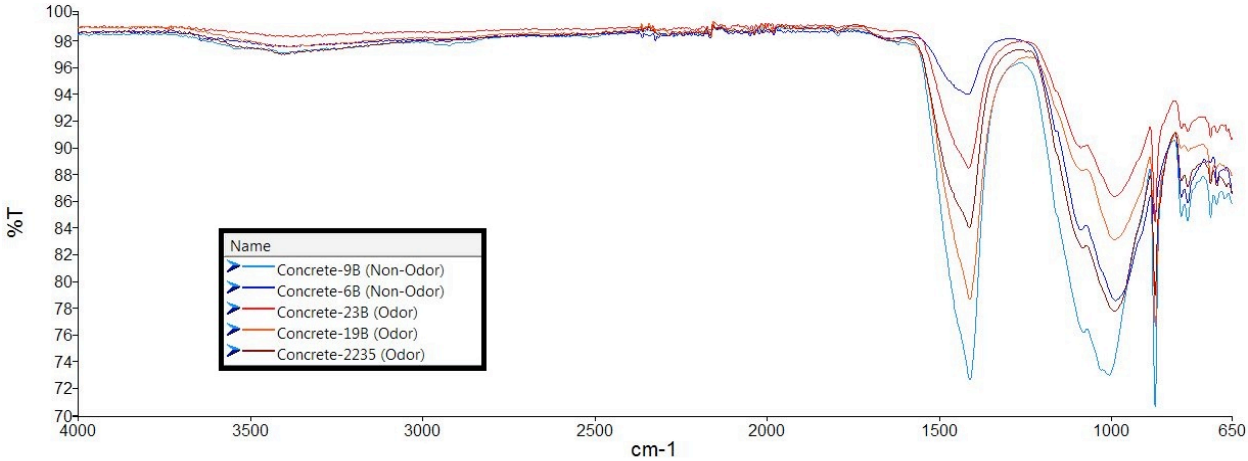


Figure 2. *FT-IR spectrum of concrete samples (Rooms 6B, 9B, 19B, 2235, 23B) as received*

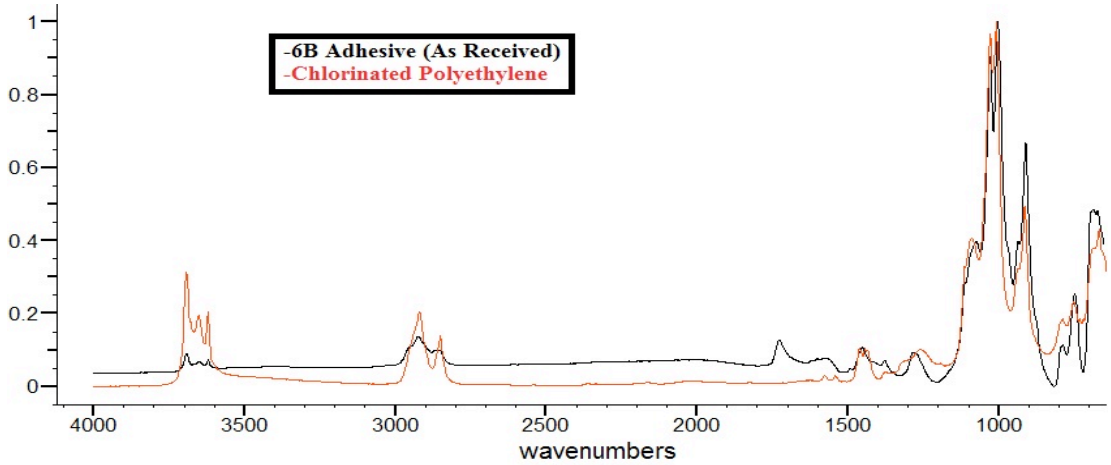


Figure 3. *FT-IR spectrum of characteristic adhesive sample (Room 6B) vs. nearest library reference standard (chlorinated polyethylene)*

Gas Chromatography/Mass Spectrometry (GC/MS) Analysis

GC/MS scans were performed on the gas released from heated adhesive samples under controlled conditions. The compounds that were volatilized by the heating process were then analyzed for the identity and quantity of the compounds presence.

Both samples displayed the sample six characteristic GC peaks in the TIC scans (See Figures 4-5). The 'non-odor' samples, taken from under a tile in room 9B, experienced higher peaks that the 'odor samples, taken from tile in room 23B. This analysis could not conclusively determine the chemical composition of the odor, due to the fact that sufficient odorous compounds could not be collected from the samples.

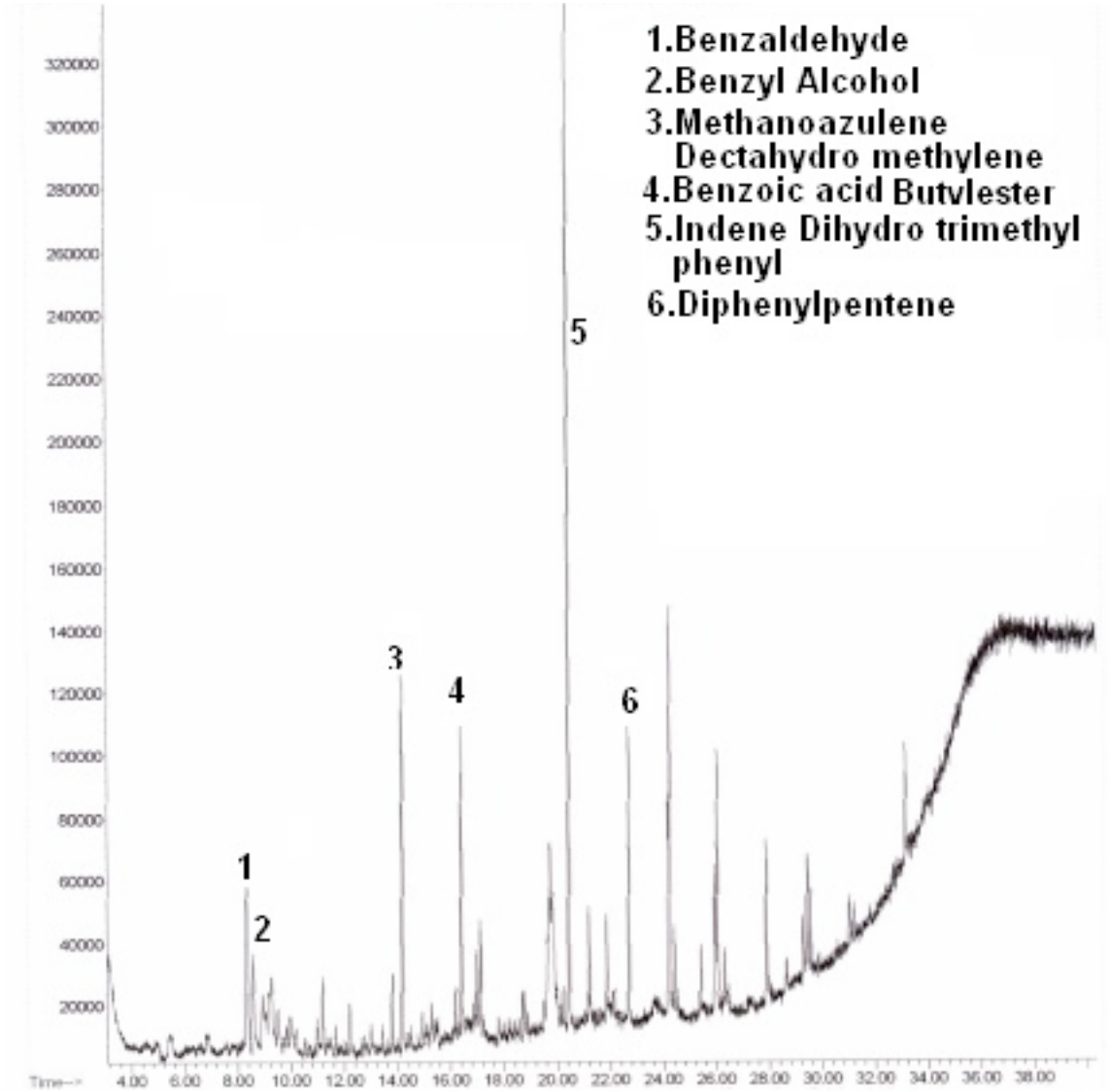


Figure 4. *Total Ion Chromatogram of headspace GC/MS analysis of adhesive from Room 9B*

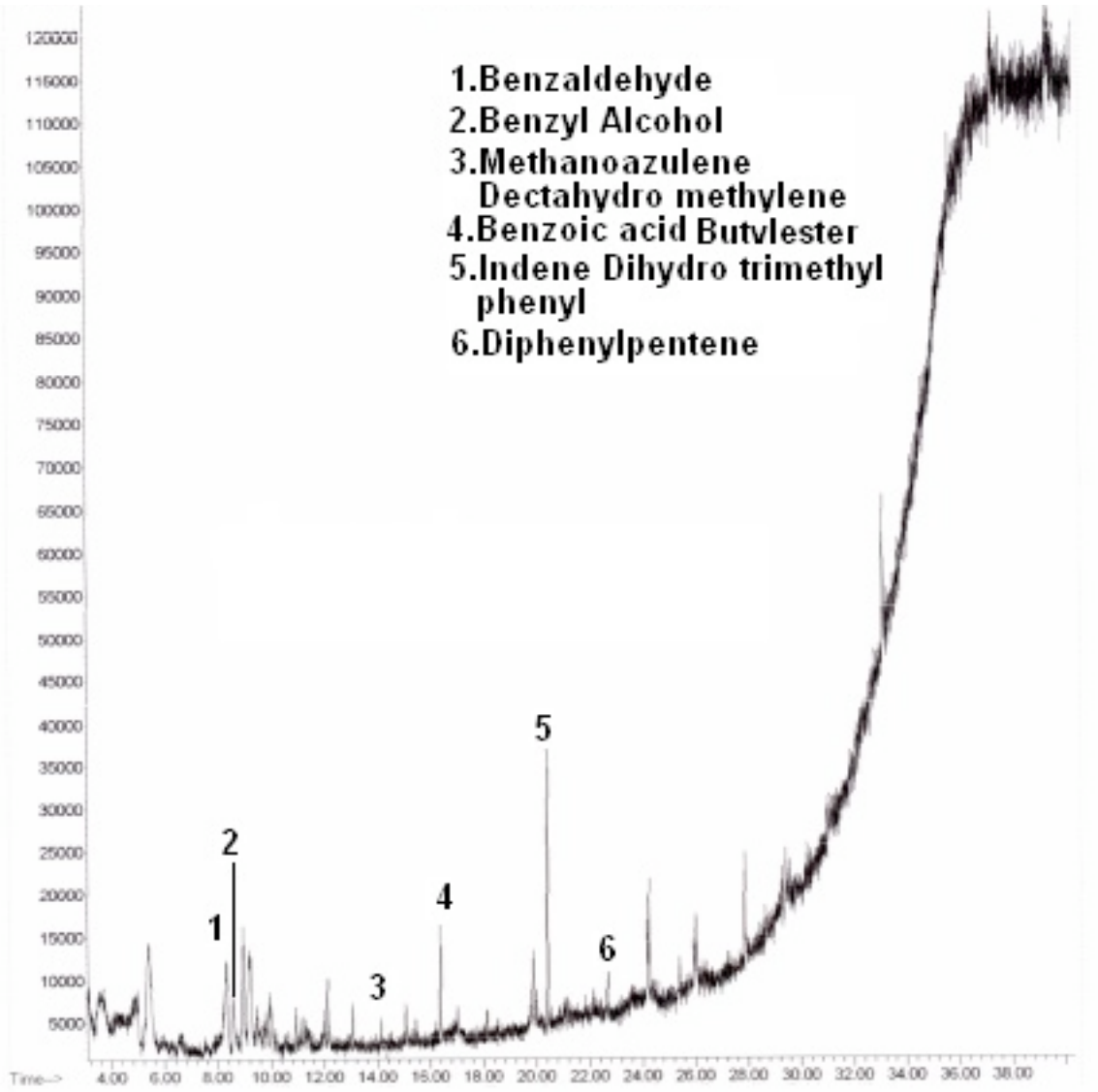


Figure 5. *Total Ion Chromatogram headspace GC/MS analysis of adhesive from Room 23B*

pH Meter Analysis:

Each concrete sample was added into standardized samples of deionized water, allowed to mix and settle, and then filtered out. Filtered water samples were then tested for pH values. Testing was performed on a Thermo Scientific Orion pH meter in triplicate for greater accuracy. The results are displayed in Table 2.

Sample	Room Description	pH
Room 9B	Labeled a 'Non-Odor' room. Exhibited some odor once tile was removed. Tile adhesive was sticky and tiles had wide seams.	10.17
Room 2235	Labeled a 'Non-Odor' room. Samples were most dry, and least odorous, of the whole building. Used as primary control sample.	10.55
Room 19B	Labeled an 'Odor' room. Dark staining on edges of tiles. Highly delaminated with a strong odor. Large amounts of adhesive.	10.81
Room 23B	Labeled a 'Non-Odor' room. Tile was easily removed in two pieces – heavily delaminated. Odor present once tiles removed. Room had supply air, which could have affected determination of 'Non-Odor'.	11.02
Room 6B	Labeled an 'Odor' room. Highly delaminated. Odor present.	11.20

Table 2. *pH values of five concrete samples, as received*

Energy-Dispersive X-ray (EDXA) Analysis:

Energy-Dispersive X-ray Analysis (EDXA) was performed on four concrete samples, from rooms 9B (control samples) and 19B, 2235, and 23B (suspect samples). We found that the ratio of calcium in the concrete samples relative to the silicon and oxygen levels was highest in the odor sample (up to 2:1) while much lower in the control sample 9B (~1:1).

This increased level of calcium in the sample could be the cause of the higher pH values in the concrete. Concrete composition and pH values should be monitored during the installation process of any future tiling projects. Concrete with high pH levels could be treated or coated to prevent future degradation of the tile adhesive.

See pages 8-9 for the FT-IR spectra described in this section (Figures 6-9)

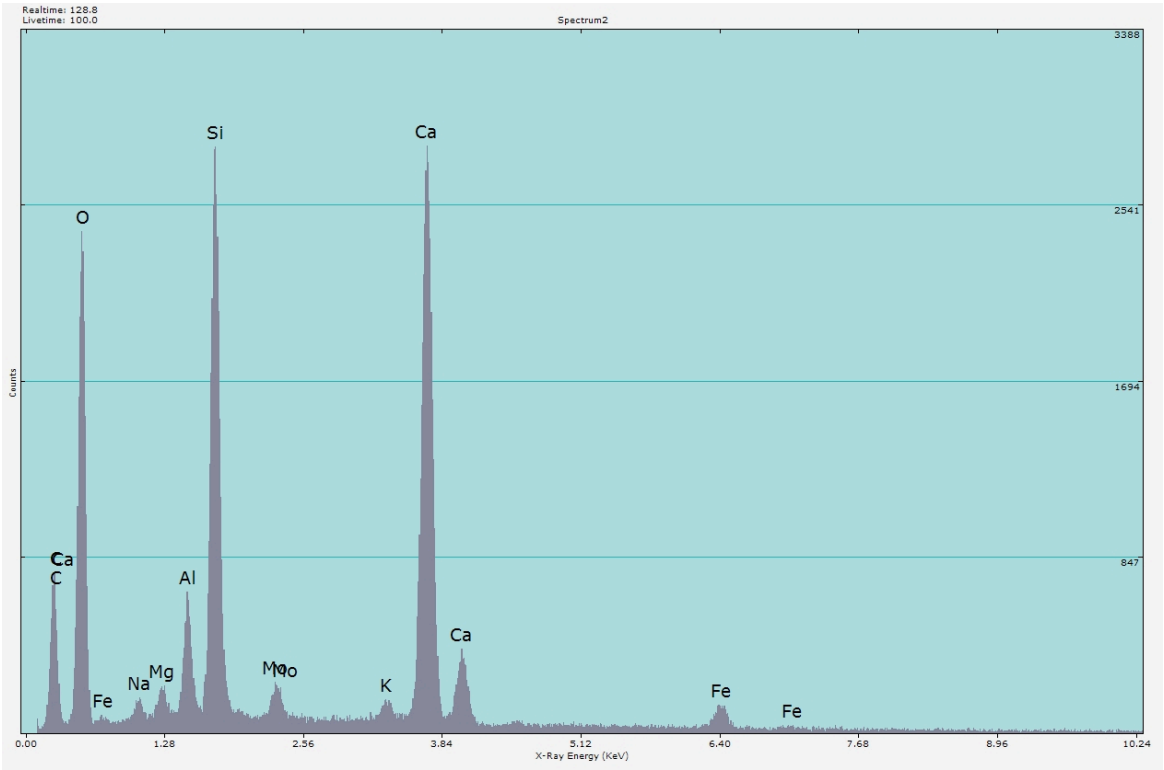


Figure 6. *EDXA scan of concrete sample from Room 9B, as received*

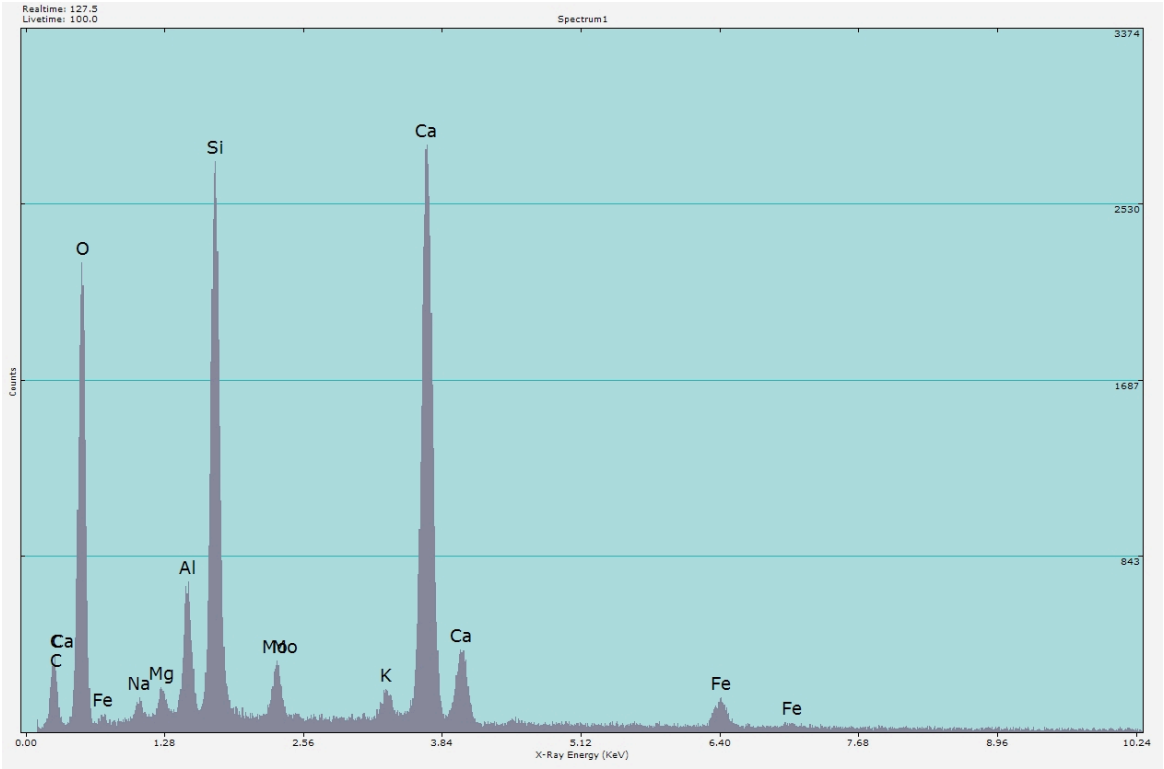


Figure 7. *EDXA scan of concrete sample from Room 2235, as received*

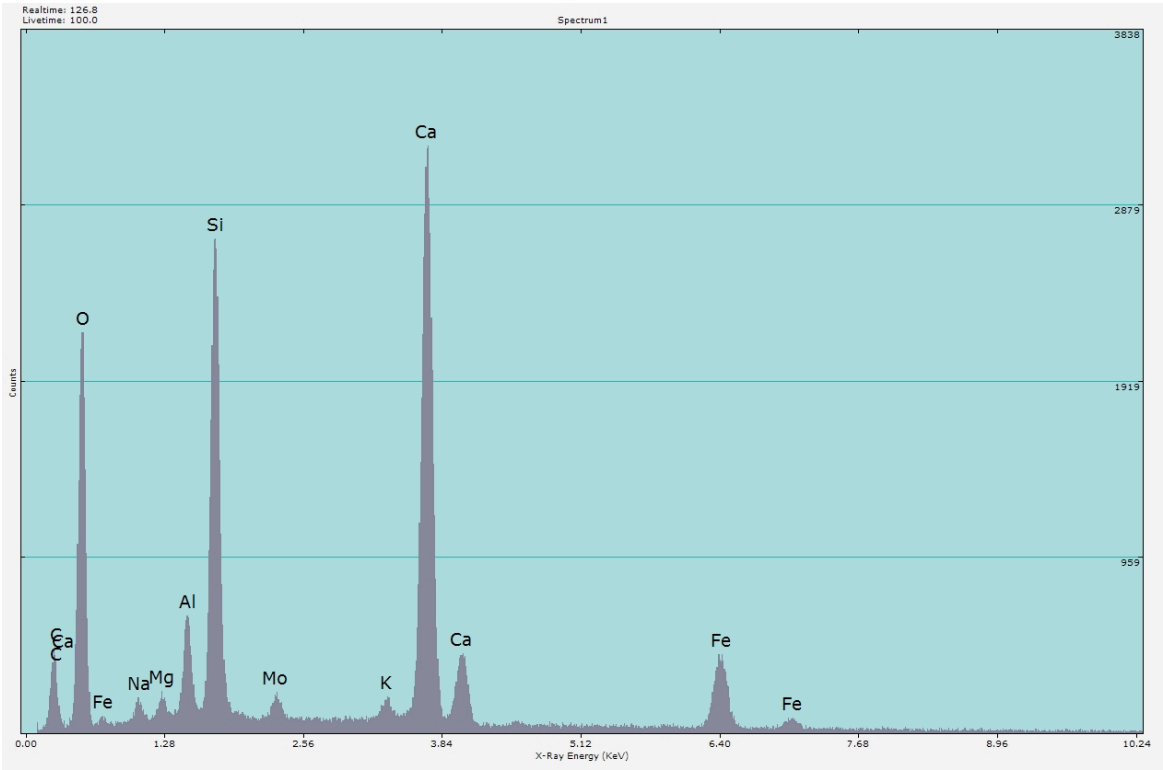


Figure 8. *EDXA scan of concrete sample from Room 23B, as received*

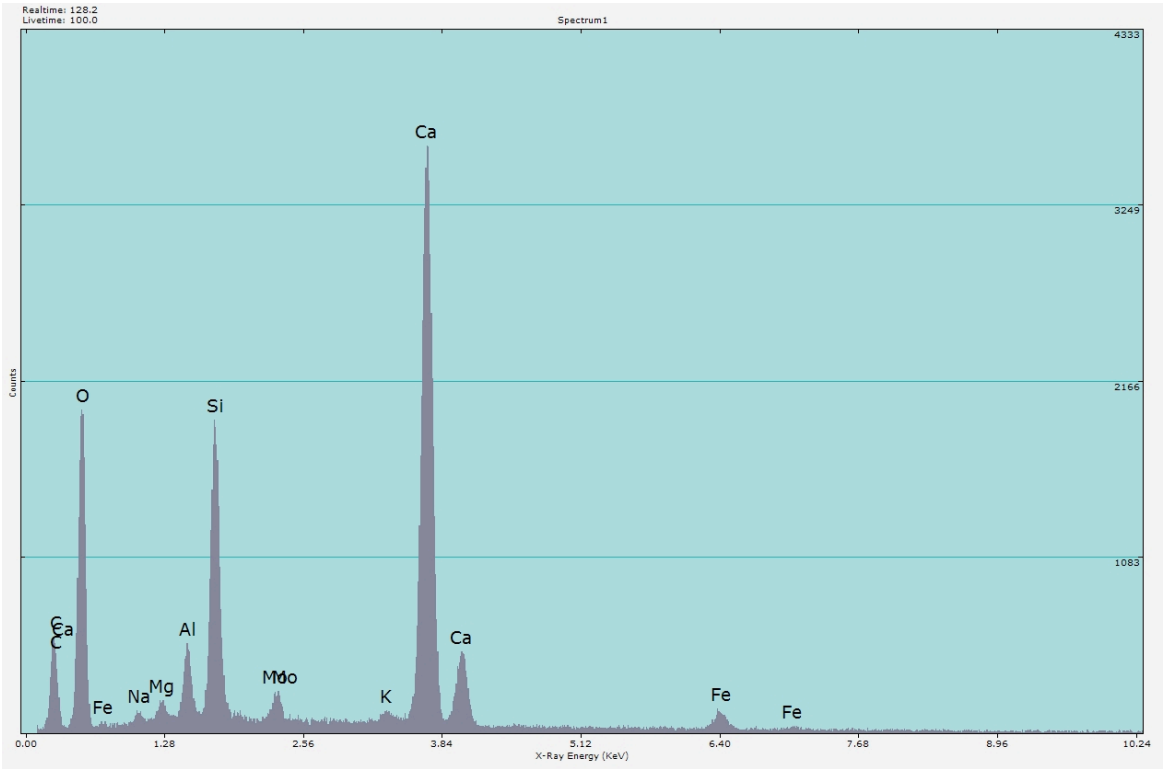


Figure 9. *EDXA scan of concrete sample from Room 19B, as received*

Description of Instrumentation Used:

Fourier Transform Infrared Spectrometer (FT-IR): Avomeen utilizes FT-IR technology to obtain molecular fingerprints of unknown compounds, using transmittance measurements captured after firing an infrared laser beam at the sample compounds. Unknown fingerprints are then searched against a database of over 230,000 known FT-IR spectra in order to develop a conclusive identification. Avomeen's state-of-the-art PerkinElmer Spectrum 65 FT-IR is equipped with an Attenuated Total Reflectance (ATR) accessory, which allows our scientists to use diamond cell technology to test solid, liquid, or gas state samples in their natural state at much lower sample sizes.

Gas Chromatography/Mass Spectroscopy (GC/MS): GC/MS testing allows for the analysis of samples along multiple dimensions of chemical properties, providing specific identification of the different compounds separated during the GC analysis. The gas chromatograph separates a complex mixture into its individual components and delivers each one to the mass spectrometer. This analysis generates a chromatogram consisting of different peaks, one for each component of a mixture. The area of each peak is used to measure quantity. GC/MS analysis can be used both for qualitative and quantitative determinations of chemical composition.

Energy-Dispersive X-Ray Analysis (EDXA): EDXA is an analytical technique used for the elemental analysis or chemical characterization of a sample. When connected to a Scanning Electron Microscope, it is able to rapidly perform elemental analyses on different areas of the sample. A detector is used to convert X-ray energy into voltage signals; this information is sent to a pulse processor, which measures the signals and passes them onto an analyzer for data display and analysis.

Wrap Up

Thank you for consulting with Avomeen Analytical Services. If you have any questions regarding this analysis, or if we can be of any further assistance, please call us at (800) 930-5450. At the conclusion of this project, the samples will be returned to you, unless otherwise instructed by your company. We have received full payment for this testing report.

It has been a pleasure to work with you and we look forward to serving you again.

Sincerely,
Avomeen Analytical Services

Shri Thanedar

Shri Thanedar, Ph.D.
CEO/Chief Chemist
800-930-5450
sthanedar@avomeen.com