STREET PAVING:
City work not meeting pavement quality standards

A REPORT FROM THE CITY AUDITOR
October 2006

Office of the City Auditor
Portland, Oregon

CITY OF

PORTLAND, OREGON

OFFICE OF THE CITY AUDITOR
Audit Services Division

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October 6, 2006

TO: Tom Potter, Mayor
Sam Adams, Commissioner
Randy Leonard, Commissioner
Dan Saltzman, Commissioner
Erik Sten, Commissioner
Susan Keil, Director, Portland Office of Transportation

SUBJECT: Audit – *Street Paving: City work not meeting pavement quality standards*, Report #324D

Attached is Report #324D containing the results of our fourth in a series of audits on Portland's street paving program. This report evaluates how the City is meeting pavement quality standards in the street preservation program. The audit was included in our annual audit schedule and was conducted in accordance with generally accepted government auditing standards.

As a follow-up to our recommendations, we ask the Director of the Portland Office of Transportation provide a status report in one year, detailing steps taken to address the report's recommendations. This status report should be submitted to the Audit Services Division and coordinated through the Commissioner in Charge of Transportation.

We appreciate the cooperation and assistance we received from personnel in the Portland Office of Transportation and the Bureau of Maintenance in conducting this audit.

GARY BLACKMER
City Auditor

Audit Team: Drummond Kahn
Doug Norman
Beth Woodward

Attachment

STREET PAVING:
City work not meeting pavement quality standards

Summary The Street Preservation Program of Portland's Office of Transportation (PDOT) paves approximately 50 miles of Portland streets each year. The Program purchases about 100,000 tons of asphalt and utilizes in-house paving equipment and personnel to perform this work. Our review of tests performed on 2003, 2004, and 2005 paving projects revealed that a high percentage of newly-paved streets did not meet City quality standards. Two-thirds of samples tested for the quality of asphalt mix (of sand, gravel, and asphalt binder) did not meet City specifications. In addition, nearly 60 percent of pavement density tests failed to meet City standards. These failures mean the City's paving work may not last as long as it should, leading to increased work and higher costs, as well as inconvenience to the public due to poorer street conditions and more frequent paving.

We reported in our 1988 audit of Street Maintenance that 83 percent of newly-paved streets we tested had low pavement density. We also found problems with the mix of asphalt purchased from asphalt supply companies. In response to our audit, PDOT began testing the mix of asphalt obtained from asphalt suppliers, added inspectors to its paving crew, and began testing the density of newly-paved streets. While these steps are commendable, we found that PDOT has not taken sufficient corrective action when tests have shown that asphalt mix and/or pavement density fail to meet City requirements.

The Street Preservation Program does not have a written plan or clear procedures for staff to follow in responding to substandard pavement quality. When a serious problem arises, a Street Preservation inspector or manager typically contacts the asphalt supplier and asks

the supplier to improve the asphalt mix or asks for suggestions on how to improve pavement density. Moreover, some provisions in the City's Standard Construction Specifications are not consistent with current practice.

PDOT needs to take additional steps to ensure that its in-house paving projects produce acceptable pavement quality. To help achieve high pavement quality and reduce future maintenance costs, we recommend that the Street Preservation Program:

- Prepare and follow a pavement quality assurance plan that outlines procedures and individual responsibilities for monitoring asphalt quality and taking remedial action when asphalt is found to be substandard.
- Develop clear and complete specifications for the desired quality of asphalt mix.
- Increase in-house technical expertise on pavement design and quality; provide more training to Street Preservation personnel; and include pavement quality in performance measures and employee evaluations.

PDOT's paving program

PDOT's Street Preservation Program maintains and repairs Portland's paved street network that includes over 3,900 lane miles and is valued at $3.6 billion. With a budget of $15.2 million in FY 2005-06 and 90 employees, the Program employs a variety of techniques – ranging from sealing cracks and patching holes to base repair and street resurfacing – to help preserve the condition of streets. Street Preservation's in-house personnel and equipment pave approximately 50 miles of Portland streets each year. This work requires the purchase of approximately 100,000 tons of asphalt a year, costing over $3 million in 2005-2006.

Achieving pavement quality

The life of asphalt pavement depends in large part on the quality of materials and processes used during construction. When pavement fails to meet minimum quality requirements, it is likely to deteriorate more rapidly than pavement of good quality, leading to increased

City paving crew applying a pavement overlay

Source: Audit Services Division photo

work over time, higher costs, and inconvenience to the public due to poorer street conditions and more frequent paving.

To achieve desired pavement quality, a quality assurance plan for inspection and follow-up needs to be established. The Federal Highway Administration (FHWA) states in its 2004 C*onstruction Program Management and Inspection Guide*,

> "Quality assurance is the systematic processes necessary to ensure the quality of a product is what it should be. Quality assurance is an all-encompassing term that includes quality control, acceptance, independent assurance, dispute resolution, and the use of qualified laboratories and qualified personnel."

Requirements for quality assurance, as listed in the FHWA Guide, include testing, inspection, records, personnel qualifications for managers, and qualifications for those doing inspection and testing. A quality assurance plan should also describe the roles and responsibilities of all involved individuals and expected communication.

PDOT typically obtains asphalt for paving by contracting with local asphalt suppliers, and its authority to control the quality of asphalt mix (of sand, gravel, and asphalt binder) used for paving is dependent on the language in these contracts. The quality of materials that suppliers agree to deliver is documented in the contracts where reference is made to the City's Standard Construction Specifications with exceptions listed as modifications, both of which incorporate parts of Oregon Department of Transportation (ODOT) specifications.

Asphalt supply companies are responsible for checking the quality of asphalt mix in order to provide mix that conforms to the limits for each size of sand and gravel (*i.e.*, gradation), asphalt cement, and temperature, as specified or referenced by contract. The mix is tested by passing it through sieves of various sizes to measure proportions of components, and processing it to determine oil content. In addition, ODOT tests the strength and other component properties for compliance with its mix formula requirements.

PDOT checks the quality of asphalt mix by taking samples at the paving site and having them tested at the City's Materials Testing Laboratory. In addition to checking mix gradation against ODOT requirements, Laboratory personnel calculate each sample's maximum possible density. This calculation allows Street Preservation inspectors to determine how close City crews are to meeting the standard for pavement density specified in the City's Standard Construction Specifications. Inspectors use specialized equipment to measure asphalt density while on site.

Low pavement quality found in 1988 audit

We found in our 1988 audit of the City's street maintenance function that 83 percent of newly-paved streets tested had low pavement density and that the mix of asphalt purchased from asphalt supply companies was not being tested by PDOT. In response to our audit, PDOT began testing the mix of asphalt obtained from suppliers, added inspectors to its paving crews, and began testing the density of newly-paved streets.

Objectives, scope and methodology

Our objective in conducting this audit was to determine if PDOT was achieving an acceptable level of pavement quality in its in-house street resurfacing projects. We also wanted to evaluate the adequacy of Street Preservation's quality assurance activities. To achieve these objectives, we observed paving operations performed by Street Preservation Program personnel and analyzed asphalt quality test results and daily reports for paving performed from 2003 through 2005.

In addition, we interviewed personnel in PDOT, the City's Materials Testing Laboratory, and the Oregon Department of Transportation (ODOT). We reviewed PDOT's asphalt supply contracts, City and ODOT standard specifications pertaining to asphalt pavement, and quality assurance guidelines published by the Federal Highway Administration (FHWA) and ODOT.

We conducted our work in accordance with generally accepted government auditing standards.

This report addresses the quality of pavement constructed by PDOT, and related management activities that affect pavement quality. It does not address PDOT's contracted paving work, which is not managed by the Street Preservation Program. Recent related reports issued by this office include Report #324A regarding compliance with Oregon's least cost statute (ORS 279C.305), Report #324B regarding funding of the Street Preservation Program, and Report #324C regarding management of PDOT's asphalt supply contracts.

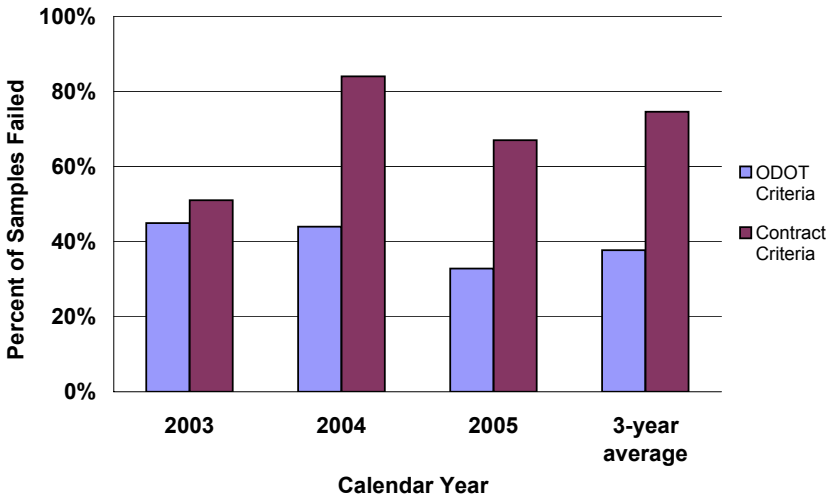
Pavement not meeting quality requirements

We found from our review of pavement quality tests performed on Street Preservation's paving projects over the last three years that about two-thirds of asphalt supplied to the City did not meet asphalt mix contract requirements. In addition, nearly 60 percent of new pavement tested did not meet City density requirements. Because quality standards describe minimums and maximums allowed, and not simply targets, we believe this lack of compliance is significant and unacceptable. Substandard pavement can be expected to deteriorate faster because pavement strength depends on the proper

mix of the right components, and on having enough density to keep water and air from breaking it down. Deteriorating pavement jeopardizes the base layers the pavement is intended to protect, leading to significantly higher maintenance costs.

Portland's Materials Testing Laboratory uses ODOT specifications for assessing asphalt mix compliance. Because City specifications are more restrictive than ODOT's in the amount of very fine material allowed in the asphalt mix, the failure rate we found when applying City specifications is higher than the rate reported by the City's laboratory. In 2005, one-third of samples tested failed to meet ODOT gradation requirements, while two-thirds failed to meet City requirements. In 2004, 44 percent of samples tested failed to meet ODOT criteria, while 84 percent did not meet City criteria. See Figure 1 for asphalt mix test results over the past three years.

Figure 1 Asphalt mix test results - percent of samples failed

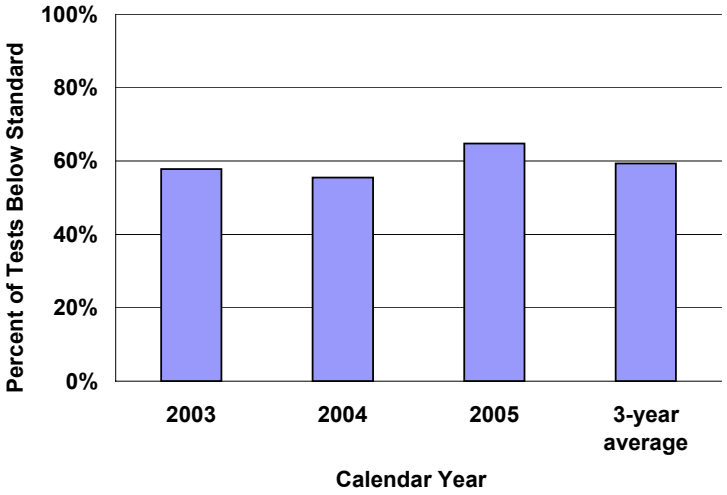


Source: Auditor interviews and analysis of PDOT records

Note: ODOT and City contract specifications differ in the amount of fine sand and silt allowed in the mix, or the amount passing the #200 sieve. ODOT allows up to 10 percent fines by weight whereas the City's specifications and contracts allow no more than 7 percent. Although ODOT allows a higher percentage of very fine material (dust), it also requires additional tests to determine asphalt mix quality on its projects. Portland's Standard Construction Specifications for asphalt mix were adopted from ODOT specifications before the latter were modified to incoporate Superpave asphalt mix specifications and the associated volumetric tests. PDOT does not require or perform the additional volumetric tests that ODOT requires.

When Street Preservation crews are paving, inspectors test the density of the top layer of asphalt immediately after compaction using a Troxler Nuclear Density Gauge. Inspectors documented 1,539 density tests in 2005 in their daily asphalt overlay reports. Sixty-five percent of these tests did not meet the City's density standard, as shown in Figure 2. Of the 1,258 density tests reported for 2004, and the 1,002 tests for 2003, 55 percent and 58 percent, respectively, failed to meet the density standard.

Figure 2 Pavement density tests – percent below standard



Source: Auditor interviews and analysis of PDOT records.

Note: Each test result is the average of two measurements taken at a single location, one in line with the paving direction and one perpendicular to the paving direction. Test results of 90.6 percent or higher are considered passing. The overall average pavement density for test locations in 2005 was 89.1 percent, which indicates that constructed pavement has 21 percent greater air voids than the 91 percent specified as minimum, contributing to pavement deterioration.

Reasons for inadequate pavement quality

PDOT and Laboratory staff said there are several reasons why paving crews are having difficulty meeting the density standard:

- Existing pavement beneath the new pavement may have variations in the surface, making it difficult to achieve uniform compaction.
- The density of thin layers of asphalt pavement is difficult to measure, even using specialized equipment, and thin layers of asphalt mix may cool too quickly to achieve required density.

- The timing of placement and compaction is critical for thin asphalt layers, and mix temperatures are affected by delivery conditions as well as air temperature.

We believe that poor mix quality could also be contributing to low pavement density. In addition, if the underlying pavement or base material is not uniformly strong enough to support compaction of new material, this could also lower pavement density. In Report #324B released in July 2006, we reported that the Street Preservation Program had sometimes performed base repairs prior to paving that were less extensive than work actually needed.

Another factor that can affect pavement density is asphalt mix temperature, which must be within a specific range at the loading site. Inspectors measure temperature at the paving site when mix samples are taken. However, the City does not check temperatures at the plant, so temperature there is not available for review and may exceed the specified range.

In addition, the Street Preservation Program does some work in colder weather that helps maximize paving production during warm weather. Such winter work includes grinding asphalt for recycling and paving base layers where needed as part of street rehabilitation. This winter paving is sometimes done when the ambient temperature is too low according to standard specifications, and no quality tests are performed of this work. Such work could also contribute to substandard pavement quality.

Other factors that affect pavement quality include the type and amount of asphalt binder, and compaction equipment and practices. Records provided by Street Preservation indicate that the number of compaction rollers available can vary on different days, which could impact rolling practices.

Lack of a quality assurance plan

Regardless of the specific cause for low density on a particular paving project, we believe an underlying problem is that Street Preservation management has placed too little emphasis on achieving pavement quality. Managers have not developed a written plan or clear pro-

cedures for staff to follow in responding to substandard pavement quality. When a serious problem arises, a Street Preservation inspector or manager typically contacts the asphalt supplier and asks the supplier to improve the asphalt mix or asks for suggestions on how to improve pavement density. Despite the high percentage of samples not meeting requirements, rejection by City staff occurs less than one percent of the time. Rejections have occurred when the mix temperature was outside the range allowed, or when the asphalt was clearly substandard. Street preservation managers state that there is little they can do because gradation test results are not available for days or weeks after paving (samples are taken during paving and delivered to the City laboratory for testing).

We also found that roles and responsibilities in PDOT regarding pavement quality were unclear. Paving inspectors work under the direction of a Supervising Engineer, but report to crew leaders during paving operations. Crew leaders report to yet another supervisor, who told us that inspectors should guide roller operators. As a result, workers are uncertain whether inspectors, crew leaders, or supervisors are responsible for addressing pavement quality problems.

Problems with standards and specifications

From our interviews, we found confusion among Street Preservation managers regarding which specifications to follow – ODOT's or the City of Portland's. In addition, we found omissions, errors, and inconsistencies in both the City's Standard Construction Specifications and its asphalt supply contracts. The City's Standard Construction Specifications are generally written for contracts under which the contractor performs the work, rather than for work done by City crews. Consequently, many of the standard provisions for acceptance, payment, or withholding payment do not apply to the supply of asphalt.

We also found a lack of clarity in temperature requirements in technical portions of the City's specifications. In addition, the asphalt supply contracts refer to specifications that are outdated and no longer valid, and to specifications with limits that may be valid but are not used in practice. It appears that a technical review of PDOT's asphalt supply contracts has not been performed for more than ten years.

Our report #324C, *Street Paving: Current contract management practices put asphalt price and supply at risk*, which we issued in September 2006, describes other findings regarding asphalt supply contracts.

Conclusions and Recommendations

PDOT initiated several steps to track the quality of asphalt mix and pavement density, in response to our 1988 audit. While it hired inspectors and began testing pavement quality, PDOT has not developed a comprehensive pavement quality assurance plan. Street Preservation personnel are unclear about their roles and responsibilities regarding pavement quality. Although tests of asphalt mix and pavement density from 2003 through 2005 showed a high rate of failure to meet requirements, very little action was taken to reject substandard asphalt. As a result, the City is paying for paving work that is often less than optimal quality. In turn, the time and cost associated with maintaining City roads will increase, and the public will be inconvenienced by poorer street conditions and more frequent paving.

PDOT needs to take additional action to ensure that its in-house paving projects produce acceptable pavement quality. To help achieve high pavement quality and reduce future maintenance costs, we recommend that the Street Preservation Program:

1. **Prepare and follow a pavement quality assurance plan that outlines procedures and individual responsibilities for monitoring asphalt quality and taking remedial action when asphalt is found to be substandard.**

   The Street Preservation Program needs a written plan that explains the specific actions staff and managers should and will take to assure that asphalt mix, pavement density, or other products meet quality standards. The plan should identify the roles and responsibilities of all personnel involved in verifying quality and responding to substandard quality, and should describe key activities such as testing and notification procedures by both City staff and asphalt suppliers. The plan should also list acceptance and rejection criteria, as well as corrective measures, such as actions to take when gradation tests show substandard asphalt mix.

2. **Develop clear and complete specifications for the desired quality of asphalt mix.**

Specifications are the means of providing asphalt suppliers with all the information they need to understand and meet the City's expectations for quality, including the steps that will be taken when the asphalt mix they supply does not meet those expectations. Suppliers and City employees need to know the basis for determining whether a specific quantity of asphalt mix, or section of compacted pavement, meets agreed upon standards. Elements such as proportions of materials, the time allowed for acceptance or rejection, and methods for payment reductions should be included in asphalt supply contracts so expectations are clear.

PDOT officials acknowledged that pavement has not met, nor do they expect it to meet, City Standard Construction Specifications, which are incorporated in the current asphalt supply contracts. They stated that they are comfortable using ODOT's specifications and will modify the asphalt supply contracts to reflect these specifications. However, PDOT does not perform volumetric testing that is required by ODOT. As PDOT clarifies its requirements through updated specifications, it should make the standards public so City employees and the public understand them, and so vendors can adjust their prices to the required levels of quality and testing.

3. **Increase in-house technical expertise on pavement design and quality; provide more training of Street Preservation personnel; and include pavement quality in performance measures and employee evaluations.**

Street Preservation's unresolved concerns about achieving and measuring density in thin asphalt lifts, the past acceptance of substandard asphalt mix, and problems with current specifications indicate that the Program needs additional technical expertise to protect the City's investment in its pavement assets. A paving engineer specializing in maintenance could help address technical issues such as minimum lift thickness, temperature, equipment needs, rolling

requirements, and appropriate tolerances. A technical specialist could also help determine training needs for different positions. In addition, to highlight its importance, pavement quality could be included in Street Preservation's performance measures. Employee evaluations for those employees – especially managers – with key responsibilities for assuring pavement quality could also include assessment of performance relating to quality assurance.

RESPONSES TO THE AUDIT

CITY OF

PORTLAND, OREGON

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September 25, 2006

Gary Blackmer
City Auditor
1221 SW 4th Ave.
Portland, OR 97204

Dear Auditor Blackmer:

I have had a chance to review the report on pavement quality recently issued by the Audit Services Division. I want to thank you for the professional work your office has done as it has examined a series of the city's street maintenance practices.

I was assigned the Portland Office of Transportation by the mayor one year ago. Since then, I have worked to ensure that this agency is spending taxpayer dollars as efficiently and effectively as possible. Indeed, it was because of this effort that I requested your office look into our pavement practices generally.

The information provided in this audit will help guide me in currently underway efforts to institute international "best practices" within PDOT in regards to infrastructure construction, management, and maintenance.

With the current budgetary challenges PDOT faces, it is absolutely essential that all work we perform maximizes the life of the infrastructure being protected and does so on the most cost-effective schedule possible. While I have been advised by staff that when asphalt specifications are not met by the contractors we rely on, it is our current practice to seek and recover costs from those contractors, I believe that we should nonetheless do more on the front-end to reduce the frequency with which this happens. We should not ever pave Portland's streets with substandard asphalt, especially if this reduces the effective life of the roadways.

I want to thank you again for the work you've done and for giving me a chance to share my thoughts on it. This report dovetails well with efforts already underway at PDOT, and will definitely be incorporated into our work in this area. Both your findings and recommendations will be of great help to me moving forward. They are also a great benefit to the citizens of Portland who demand and deserve the best from their city government.

Best,

Sam Adams
Portland City Commissioner

Cc: Portland City Council
Sue Keil, Director, PDOT
Sam Irving, Director, BOM
John Rist, Business Operations Division Manager, PDOT
Liane Welch, Street Preservation Division Manager, BOM

CITY OF
PORTLAND
OFFICE OF
TRANSPORTATION

September 28, 2006

Gary Blackmer
City Auditor
1221 SW 4th Avenue
Portland OR 97204

Dear Mr. Blackmer:

The Portland Office of Transportation is pleased to respond to the audit addressing poor pavement quality. I appreciate the independent review and work of the Audit Services Division. In our efforts to efficiently maintain and improve Portland's transportation system, it is important to ensure that our in-house paving projects produce acceptable pavement quality.

The audit makes three recommendations for improvements, which PDOT supports. PDOT will:

- Prepare and follow a pavement quality assurance plan that outlines procedures personnel should follow to monitor asphalt quality and to take remedial action when asphalt is found to be substandard.
- Develop clear and complete specifications for asphalt mix.
- Increase in-house technical expertise on pavement design and quality; provide more training of Street Preservation personnel; and include pavement quality in performance measures and employee evaluations.

These efforts will improve our ability to provide quality street maintenance work.

PDOT will improve its procedures for assuring that asphalt mix, pavement density, or other products meet quality standards. Elements such as proportions of materials, the time allowed for acceptance or rejection and methods for any payment reductions shall be included in all new asphalt supply contracts. PDOT will employ necessary additional technical expertise to protect the City's investment in its pavement assets. And, performance measures for the City's Street Preservation Program will be changed to include metrics indicating pavement quality.

I appreciate the thorough review of our quality assurance/quality control efforts. PDOT will make every effort to implement the changes recommended by the audit.

Sincerely,

Susan D. Keil

Susan D. Keil
Director

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Cc: Commissioner Sam Adams
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Liane Welch, Street Preservation Division Manager, BOM

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Street Paving: City work not meeting pavement quality standards

Report #324D, October 2006

Audit Team Members: Doug Norman
Beth Woodward

Gary Blackmer, City Auditor
Drummond Kahn, Director of Audit Services

Other recent audit reports:

Street Paving: Current contract management practices put asphalt price and supply stability at risk (#324C, September 2006)

Financial Transaction Review: Few results identified for further study (#334, August 2006)

Street Paving: More proactive maintenance could preserve additional city streets within existing funding (#324B, July 2006)