Performance Audit: City Using Pavement Data to Improve Streets

July 2011

City Auditor
City of Lawrence, Kansas

July 21, 2011

Members of the City Commission

The city is using specifications and pavement condition data to improve the condition of city streets. Respondents to the 2011 citizen survey identified maintenance of streets/sidewalks/infrastructure as the service that should receive the most emphasis in coming years.

The city raised the standard for construction of new streets in 2003 and streets built to that standard last longer and have fewer potholes. While the city strengthened the standard in 2003, some other area communities had raised their standards years before Lawrence.

Public Works monitors and revises specifications for building and maintaining streets. Specifications are important because they affect how well the pavement performs.

Objective pavement data guides decisions about where and how the city maintains streets. Objective data helps the city determine the right maintenance for the right street at the right time. Good maintenance decisions can prolong the life of the pavement and avoid costly rehabilitation of streets.

The city should establish guidance on maintaining streets that are brick and asphalt over brick. Guidance would help the city better maintain those streets. Currently the city does not have a plan for brick street maintenance. While these brick streets represent a small part of the city's street system, they are concentrated in one part of town and are in relatively poor condition.

I provided the City Manager and Director of Public Works with drafts of this report. The City Manager's written response is included in the report.

I appreciate the cooperation and assistance I received from the Public Works Department and Information Systems Department as I conducted this performance audit.

Michael Eglinski
City Auditor

Performance Audit: Using Pavement Data to Improve Streets

Table of Contents

Performance Audit: Using Pavement Data to Improve Streets

Results in Brief

The city raised the standard for construction of new streets in 2003, and analysis of those streets shows that streets built to the new standard perform better. The change – requiring a different subgrade construction – resulted in streets that decay slower and have fewer potholes. Road users should experience a smoother ride on those streets. While the city strengthened the standard in 2003, some other area communities had raised their standards years before Lawrence.

Public Works monitors and revises specifications for building and maintaining streets. The City Engineer acts as the main point of contact for changes to specifications. The City Engineer seeks input from staff and other stakeholders to identify needed changes. While this process is not formally established by policy, a review of specifications from recent years shows that the process results in changes to the specifications.

Objective pavement data guides decisions about where and how the city maintains streets. A review of 580 decisions about maintenance in 2010 indicates that the majority of streets clearly fit within maintenance categories based on the objective pavement scores. Some streets included in the plans had previously been identified for maintenance or were included as part of a geographic group of streets that require maintenance.

Establishing guidance on maintaining streets that are brick and asphalt over brick would help the city better maintain those streets. Currently the city does not have a plan for brick street maintenance. While these brick streets represent a small part of the city's street system, they are concentrated in one part of town and are in relatively poor condition.

Performance Audit: Using Pavement Data to Improve Streets

City Raised Standard for New Roads in 2003; Roads Built to New Standard Perform Better

The city raised the standard for construction of new streets in 2003, and streets built to the new standard have performed better. Beginning in 2003, new streets in the city have been built with flyash treated subgrade. Based on recent street inspection data, the flyash treatment has improved the performance of streets, which should reduce the city's costs to maintain those streets. Road users should experience a smoother ride on streets built with flyash treated subgrade.

Flyash Subgrade

New streets in Lawrence are built in two main layers:

- Surface pavement of either concrete or asphalt
- Flyash treated compacted subgrade

The flyash subgrade forms a foundation for the pavement. Prior to 2003, the city didn't require flyash subgrade treatment to support the pavement. Instead, pavement was placed on top of compacted dirt.

Power generating plants that burn coal create ash. The smaller ash particles are referred to as flyash. Flyash reacts with water and hardens, much like cement. In subgrade, flyash is strong and durable, producing a quality stabilized layer.

The U.S. Department of Environmental Protection has encouraged the use of flyash in construction, in part because it reduces the need to dispose of flyash in landfills.

To test whether streets built with subgrade treatment performed better, the City Auditor compared streets built in 2002 and 2003. The auditor reviewed pavement conditions.[1] Streets were put into groups based on the

[1] The analysis relied on pavement inspection data compiled and maintained by the Public Works Department. City inspectors look for visible distresses – such as cracks and

subgrade construction and whether they were residential or non-residential streets. Comparisons were made of the annual rate of deterioration and the specific problems present. Because the streets are relatively new, differences would be expected to be small, but those differences are likely to increase in the future as the streets age. The analysis found that non-treated subgrades aged faster and had more potholes and settlements. See Table 1.

Table 1 Performance of Streets with Flyash Subgrade

	Residential	Non-residential
Pavement rating	Perform slightly better (about 0.1 PCI point per year)	Perform better (about 1 PCI point per year better)
Pavement defects	Have fewer potholes and settlement, but more rutting	Have fewer potholes, rutting and fatigue, but more settlement.

Streets built without a treated subgrade are more likely to have potholes. Without subgrade treatment, most streets will have potholes. See Table 2. In addition to a bumpier ride, the city will have to spend more to fill potholes on non-treated streets.

Table 2 Percent of Streets with Potholes

	Residential	Non Residential
No treatment	51.1	76.9
Fly ash treatment	37.5	41.2

In terms of maintenance costs, the most striking difference in performance of the new streets is that non-treated arterials and collectors are wearing out faster and will reach a critical point sooner. The city will have to spend more to keep non-treated streets in good condition. Consider two non-residential streets, one built with flyash subgrade and one without treatment. If they deteriorated at the average rates for each type of street, the one with flyash treatment would last between 25 percent and 40 percent longer before it would need crack seal, microsurface or mill and overlay.

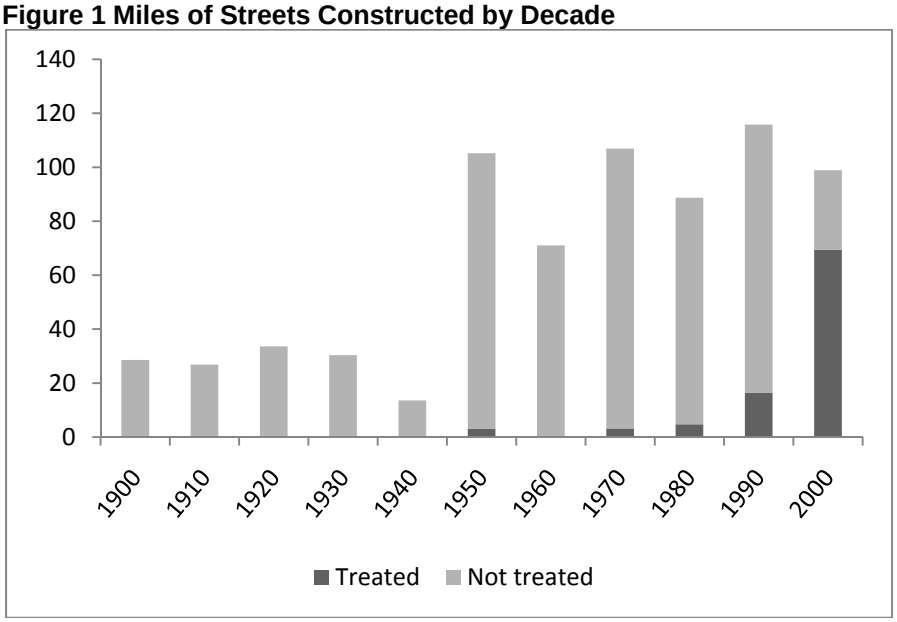
potholes - in pavements and evaluate the severity and extent of those problems. The city uses the information to calculate a "pavement condition index" (PCI) that gives an overall score between 0-100.

Table 3 Summary of Maintenance Methods

Maintenance	Benefit	Used	Cost
Crack seal Clean cracks and then fill them with a sealant	Reduces/delays moisture damage; crack deterioration; and roughness (though it can also cause some roughness and reduced friction).	PCI scores of about 55-88 1 year after construction or other maintenance and then every 5-8 years	Low $0.40 per square yard
Microsurface Add a thin layer of pavement material on top of the existing asphalt pavement	Reduces oxidation and wear of the street surface; improves friction; seals the pavement; and fills minor irregularities and surface ruts.	PCI scores of about 62-84 10-15 years after construction and at 7-10 year intervals	Medium $4.00 per square yard
Mill and overlay Remove top part of existing pavement and replace with asphalt	Removes surface problems; improves readability; creates a sealed surface; and allows for some structural repairs.	PCI scores of about 38-61 15-20 years after construction and at 10-12 year intervals	High $14.00 per square yard
Concrete rehabilitation Remove and replace the full depth of sections of pavement	Restores structural capacity; improves drainage; and improves ride quality	PCI scores of about 38-60 15-20 years after construction and as needed there after	High $84.00 per square yard

While the improved subgrade standards will help newly built streets last longer, the vast majority of streets in Lawrence were built without subgrade treatment. See Figure 1. Flyash treated subgrade was rare in the past. Only 10 percent of the 205 lane miles streets built in the 1980s and 1990s were built with treated subgrade. In the last decade, 70 percent of the newly built streets have treated subgrade.

Figure 1 Miles of Streets Constructed by Decade



Public Works Monitors and Revises Specifications

Public Works revises specifications, helping to ensure pavement performs at its best. The department provides specifications for materials and construction methods, including standard detailed drawings. Pavement failures have been associated with problems of:

- Design
- Construction
- Materials
- Maintenance

City specifications address design, construction, materials and maintenance.

Specifications are important because they affect how well the pavement performs. Strengthening the subgrade specification improved the performance of new streets. But, Lawrence lagged behind some other area communities in requiring flyash subgrade.

To test whether the city was maintaining specifications, the City Auditor reviewed recent specification documents, interviewed staff to understand the process, and attended the Public Works Department's annual meeting with contractors and consultant. Comparing specifications shows that

staff have made numerous changes, indicating that they actively maintain specifications. Changes to specifications range from major changes to reflect improvements in construction technology to minor changes to clarify language in the documents.

Changing Specifications to Address Problems

City staff noted problems with some pavement built in 2010. Some pavement built with recycled asphalt was cracking and appeared to be aging quickly. The specifications in place in 2010 allowed for contractors to use recycled asphalt for up to 20 percent of the surface and 30 percent of the base. Staff proposed changing the specifications by reducing the amount of recycled asphalt allowable. The proposed changes were shared with stakeholders and went into effect in early 2011.

The City Engineer is the main point-of-contact for changes to specifications. The City Engineer relies on input from other city staff and stakeholders to identify needed changes. Stakeholders include contractors and consultants who work with the city and the Kansas Department of Transportation. The Public Works Department holds annual meetings with staff, contractors and consultants to discuss possible changes and solicit input and feedback. The department began holding annual meetings in 2009. While the city's process is not formally established by policy, the city has been able to identify and make changes to the specifications.

Pavement Condition Data Guide Maintenance

Objective data on pavement conditions guide decisions about street maintenance. Public Works staff consider a range of factors when planning which streets to include in maintenance programs and when deciding the specific maintenance approach. The factors include:

- Objective pavement measures from pavement inspections (PCI ratings)
- Known problem areas
- Constituent concerns
- Coordination with other projects
- Selections throughout the community

To test whether objective pavement data guided maintenance decisions, the City Auditor reviewed 580 streets selected for maintenance in 2010 and determined the reason each segment was included. Overall, maintenance decisions were consistent with the objective pavement measures.

Out of 580 segments included in the 2010 maintenance plans, 402 fit in the expected ratings ranges. In general, the city considered streets with ratings of 38-61 for mill and overlay, and streets with ratings of 62-84 for microsurfacing. The city considers streets with a broader range of ratings, 55-88, for crack sealing.

About 30 percent of the street segments included in the maintenance plan were outside the normal ranges for maintenance. The City Auditor reviewed each of those segments to determine if staff had previously identified them as candidates for the selected maintenance; and if the segments were adjacent to other segments within the normal rating range for maintenance. The auditor also interviewed Public Works staff to understand the maintenance decisions. Based on that work the segments that had unexpectedly high or low PCI scores were segments:

- Inspectors had previously identified the street as candidates for the planned maintenance;
- Adjacent to streets that were included in planned maintenance.

Public Works often groups the maintenance of street segments when contracting for maintenance. If a street segment is adjacent to a group of

segments that are planned for maintenance, that segment may be included even if the PCI score is outside the normal PCI range. Grouping work locations geographically can result in lower overall costs. When work locations are close, contractors reduce time moving equipment and crews. Grouping work also makes it easier for project managers and inspectors.

An Example of Grouping Maintenance

A short – 250 foot - segment of East 13th was included in mill and overlay plans despite having a relatively high PCI score. The segment was included because it was adjacent to several segments of East 13th that had much lower PCI scores. The adjacent segments of East 13th had scores of 50-57, which are within the normal range for mill and overlay maintenance.

Using pavement data helps ensure efficient and effective use of resources. Maintenance decisions involve using the right maintenance, treating the right streets and treating them at the right time. Objective pavement data are key to making those decisions properly. Making those decisions properly can prolong the life of the pavement and avoid costly rehabilitation of streets.

City staff suggest that the city should develop a policy on maintaining streets with bricks surfaces or with asphalt surfaces over brick. Currently, maintenance on these streets isn't driven by the same sort of data as maintenance on other city streets. Absent a policy-driven plan, the city's practice has been to provide maintenance on an as-needed basis to address potholes and significant settlement. In recent years, the city has also done cracksealing of streets with asphalt pavement over brick. The city has also reconstructed several brick streets when funds have been available. Brick streets have lower average condition ratings that other city streets. See Table 4.

Table 4 Comparison of Brick Streets and the City as a Whole

Streets	Average Pavement Condition Index	Lane Miles
Entire street system	73	727
Brick surfaced and pavement over brick	59	46

Brick streets are concentrated in part of the city. Brick and aphalt over brick streets are generally south of 6th Street and north of 15th Street and

between Missouri Street and Pennsylvania Street. These streets are old, the average age of the brick streets is 98 years.

The city has made efforts to develop policies in the past. Staff reviewed issues, consulted with stakeholders, collected information on other communities' policies, and drafted potential policies. Despite those efforts a policy was not adopted.

Follow-Up on Pavement Conditions Measures

Pavement condition data was found to provide reliable information on the condition of city streets in the 2008 *Performance Audit: Pavement Conditions Measures*. Reliable information helps the city identify pavement maintenance and repair projects, evaluate design standards, and determine appropriate maintenance. It also provide the City Commission and the public with measures of the city's performance.

That report included four recommendations, three of which have been implemented.

The city has completed additional condition inspections and hired a part-time GIS intern; documented the pavement database; and developed a policy on backing up data.

The city has not begun to enforce the excavation permit or implemented a right-of-way management ordinance. The City Code requires a permit before making an excavation in a street or sidewalk, but the city has not been issuing those permits. The city set the permit fee at $15 in 1976. Managing the right-of-way helps minimize traffic safety concerns, avoids unnecessary traffic hindrance, and minimizes damage to infrastructure. The City Manager cited the current economic climate and staffing resources as hindrances to implementing a right-of-way management ordinance.

Recommendations

The City Auditor recommends the City Manager:

- Develop a maintenance policy for city streets paved in brick and with pavement over brick.

Performance Audit: Using Pavement Data to Improve Streets

Scope, methods and objectives

This performance audit was designed to answer:

- Did specification changes related to subgrade treatment result in better pavement conditions?
- How does the city ensure specifications are appropriate?
- Does the city use the pavement condition data to guide maintenance decisions?

The City Auditor reviewed current and past city specifications; reviewed select literature on pavement maintenance; interviewed city staff; attended the annual meeting with contractors and consultants; interviewed staff in other cities; reviewed relevant data dictionaries, and analyzed databases of city street conditions and construction and maintenance histories.

The City Auditor relied on pavement condition and construction history data from databases maintained by the Public Works Department. The auditor assessed the reliability of the data by reviewing the 2008 *Performance Audit: Pavement Condition Measures*. That audit concluded that the data provide reliable information about city streets. The auditor also followed-up on recommendations from the 2008 audit that were intended to strengthen the reliability of the data. The auditor concluded that the data maintained by the city are reliable to address the audit objectives.

The City Auditor worked with the city's GIS coordinator to create a "spatially matched" database that combined pavement condition and construction history. The spatially matched database includes 3,648 street segments. The database includes 203 items describing each street segment, including the specific types and severity of defects identified during inspections, the date of the pavement inspections, the pavement condition index, the year the segment was built, the type of subgrade, and the type of street.

To evaluate the effect of the change in subgrade treatment, the City Auditor compared the annual PCI deterioration rates and defects related to

subgrade for street segments built in 2002 and 2003. The analysis involved a total of 167 street segments.

To evaluate the city's use of the pavement condition data to guide maintenance plans, the City Auditor reviewed the 2010 maintenance plan. The auditor reviewed each of 580 street segment included in the 2010 plans for mill and overlay, microsurfacing and crack sealing. The auditor identified "outliers" as street segments with PCI scores of more than one standard deviation above or below the average PCI score for each type of maintenance. The auditor did additional analysis on each outlier to determine why it was included in the maintenance plan.

The City Auditor conducted this performance audit in accordance with generally accepted government auditing standards. Those standards require planning and performing the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for the findings and conclusions based on the audit objectives. The City Auditor believes that the evidence obtained provides a reasonable basis for the findings and conclusions based on the audit objectives.

Performance Audit: Using Pavement Data to Improve Streets

Management's Response

City of Lawrence
CITY MANAGER'S OFFICE

DAVID L. CORLISS
CITY MANAGER

City Offices
PO Box 708 66044-0708
www.lawrenceks.org

6 East 6th St
785-832-3000
FAX 785-832-3405

July 13, 2011

Mr. Michael Eglinski
City Auditor
City of Lawrence, Kansas

Re: Performance Audit on Pavement Data

Dear Michael:

Thank you for your work in preparing the performance audit concerning the use of pavement condition data to improve streets. I believe the Public Works Department has made significant improvements in the specifications of materials for new streets which will provide for better performance and longer lasting infrastructure improvements. It is also important to note that public funds are being spent wisely and the appropriate maintenance techniques are used at the appropriate time extending the life of City streets/infrastructure.

I would agree with the recommendation to develop a maintenance policy for City streets paved in brick and with pavement over brick. It is appropriate to note that over the last few years staff has applied for and received several grants to reconstruct brick streets. We continue to seek those funding opportunities.

Brick streets present many challenges including historic value and the additional cost of construction and maintenance. It costs approximately three times as much to reconstruct one block in brick versus conventional asphalt/concrete ($300,000 versus $100,000). Maintenance of asphalt covered brick streets continue to be an issue. As an example, 9th Street between Massachusetts and New Hampshire is an example of a street needing maintenance; the brick under the asphalt hinders corrective measures being taken.

One possible suggestion for the policy is to provide that numbered streets (east/west) be rebuilt using concrete or asphalt, and north/south streets be rebuilt with brick. Residences predominately face the north/south streets and have a low volume of traffic. Harvesting the bricks from the numbered streets (east/west) would ensure that there are sufficient bricks for reconstruction. An important part of this issue will be whether conventional street maintenance funding should be reduced in order to provide funding for brick street maintenance. Staff will develop a policy for City Commission consideration of this issue, in conjunction with review by our Historic Preservation Administrator. The City Commission can then consider/amend/ approve a policy and staff will implement accordingly.

Sincerely,

David L. Corliss
City Manager