RW Block
Consulting, Inc.

TO: Dennis Smith, Lead Auditor, City of Milwaukee

FROM: Roy W. Block and Edgardo D. Block, PE

RE: **Additional Observations on DPW Functional Areas and Impact on Paving Program**

DATE: **May 13, 2008**

The following is a compendium of general observations and suggestions made with respect to each functional area involved with the paving program for the City of Milwaukee. They are the result of the in-situ interviews at the Department of Public Works, the documentation provided by the auditing team, field review of pavement conditions, and data analysis after the visit.

Pavement Management System

1. Strengthen the data collection quality-assurance program – focus on Rigid ("Portland-Cement Concrete," or PCC) pavements. Using the approach outlined in the May 13, 2008 memorandum on analysis of the difference in 2000-2001 versus 2006-7 pavement condition.
2. Increase the frequency of data collection: this will help avoid data "drift" due to differences in actual vs. forecasted pavement performance.
3. Adjust pavement performance curves, especially after a third data collection cycle. There is sufficient data to refine both the basis of the curve-family development (soil type, pavement thickness, and traffic volume) as well as to adjust to local pavement performance.
4. Incorporate Maintenance Treatments and analysis into the PMA. This should include the calculation of Remaining Service Life (forecast time between current condition and minimum acceptable condition as defined by the agency.)
5. Integrate project history, condition history, and pavement-related data into a single database. There are very comprehensive sets of project and construction history data in Milwaukee, but there is a corresponding significant opportunity for data integration and avoidance of having to enter and/or maintain data in separate locations. This will have to be an ongoing process moving forward and can be done in an incremental basis once the framework for data storage has been defined.
6. Provide sufficient resources to accomplish all of the above. There is only one engineer dedicated to these activities. The scope of work required is substantially more than can be accomplished by a single individual.

Design (Engineering)

1. Review flexible design standards for new construction or reconstruction. Early, progressive edge failures were observed consistently on newer flexible pavements. In addition, alligator cracking has often developed around transverse or longitudinal cracks (see images of distress presented in Appendix C.) This failure mechanism is indicative of structural weakness at these locations and suggests that the pavement section may be too thin altogether.
2. Review design procedures for placement of concrete curb. One possible cause of this early edge distress is difficulty in compacting the mix in a constrained area.
3. Review pavement design standards periodically. This should be done every time a new design practice is incorporated or every 5 years, whichever is lower. Review does not necessarily mean change, but changes in any of the design assumptions (material properties, vehicle characteristics, etc.) should be considered.
4. Incorporate innovative reconstruction technology. This includes concrete rubblization (which has to include consideration of curb height issues, so it must be adjusted accordingly) for concrete pavements and full-depth reclamation for flexible pavements. Evaluate best practices and run pilot projects as part of a new-technique evaluation process.
5. Establish a formalized process for new product and technique evaluation, in conjunction with the Office of Maintenance. This should include a list of approved products and construction techniques, a process for evaluating the performance and feasibility of each treatment. This process should also contain an idea-solicitation feature, which could be both internal via official communication or focus groups, as well as external through an internet interface or other means. The Office of Maintenance needs to be involved because of the principal role it is likely to play in implementing pavement-preservation techniques.

Construction (Inspection, Testing)

1. In some locations, raveling and stripping were observed in flexible (asphalt) surfaces. Consider measures to mitigate stripping by examining the moisture susceptibility of the aggregate.
2. At one specific location, substandard coarse aggregate was pitting and raveling after only a few years of service. This further suggests that additional emphasis should be placed on material specifications. Source aggregate properties need to be specified and inspected in order to keep substandard materials from the City's pavements. In old concrete pavements some material failures (mainly spalling and potholes) could be observed. Although the pavements have been in place for a long time in many cases, this still points to a need to focus on material quality. Aggregate tests at the source do not need to be performed daily, but the producers should be aware that the City is focusing on the quality of its materials.
3. One of the causes of the edge distress observed in newer flexible pavements could be lack of compaction next to the concrete curb. Construction procedures should be reviewed, and degree of compaction measured, to see if there is a problem in this regard.

4. In at least one location, mid-slab cracks were present in a large percentage of slabs of a newer concrete pavemnet, even with short joint spacing. One possible cause is inadequate initial joint construction.
5. Slab curling/warping were observed at some locations. Pay special attention to concrete curing during construction – it is perhaps the single most important determining factor in concrete pavement performance.
6. Joint faulting was observed. This is most likely caused by inadequate load transfer, followed by differential settlement as the support is undermined.
7. Cracked slabs and depressions suggest that the slab support is lost. Pay special attention to sealing the joints at initial construction.

Maintenance Program

1. The current focus of the maintenance program is to eliminate safety concerns due to localized or badly failed pavement, although there is a limited slurry sealing and crack-routing and sealing program that is executed according to pavement-preservation principles. This is a result of poor and deteriorating pavement conditions that the unit is charged with addressing.
2. There is a very limited toolbox of maintenance treatments implemented in the City of Milwaukee. These treatments are crack sealing, crack routing and sealing, and slurry seal. This limits the ability of the Maintenance unit of preserving the condition of the city's pavements. New techniques should be examined, evaluated, tested, and implemented continuously. These techniques are listed in the subsequent section. In addition, there is no formalized, robust mechanism for expanding the toolbox of preventive maintenance (preservation) treatments.
3. Implement a pavement preservation philosophy to pavement interventions (the right treatment to the right road at the right time.) This is going to be central to a strategy to turn around pavement conditions in residential streets in the City of Milwaukee.
4. Focus on prevention. Some treatments were applied too late into the deterioration of the pavement, including crack sealing (as on State Street downtown). Some cracks have developed earlier than expected in flexible pavement – these should be sealed to prevent the infiltration of water, given the propensity of alligator cracking forming parallel to the crack in the newer flexible pavements.
5. Set up a program to address specific localized failures. Use the PMA condition output as well as field review to identify these locations. These failures are typically low-production repairs that can be very expensive to address via contract, but the failures may drive the condition of an entire pavement segment – addressing them will tend to homogenize the pavement condition of a segment and extend the life of the entire segment.

Cost Estimating

1. With material and energy costs undergoing what appears to be significant price increases of a structural nature (namely, incraeased demand combined with decreasing supply), rapid and accurate feedback of price changes and trends is essential to maintaining credibility of the program needs assessment, especially at the higher budget levels suggested by this audit. This will increase scrutiny of program effectiveness, since other competing city services needs (or property assessments, or taxes) will be affected if the higher budget levels are implemented and will look for ways to compete for those funds.

Utility Patching

A general observation stemming from the visit to the City of Milwaukee is that utility patching is hardly compatible with the surrounding pavement and is, in many cases, the primary cause of distress, whether such distress takes place within the utility cut itself or in the surrounding pavement, particularly in flexible and macadam pavements. In those pavements, distress within the utility patch takes a variety of forms, including depression, heaving, cracking, and potholes. When the distress forms in the surrounding pavement, a common failure mode observed was alligator cracking around the utility patch edges, potholes and patches, depressions, and roughness. For rigid pavements, distress typically consists of cracks, slab depressions, or spalling at the patch edge. Even with the best construction practices, utility patching is akin to surgery; the replacement material is unlikely to have exactly the same properties, especially since construction methods for a full-width roadway and utility cuts is by nature different. Differential behavior can lead to distress and almost invariably does. The effects of utility patching are especially pronounced in MacAdam pavements, which exhibit structural behavior that is not easily replicated through either flexible or rigid pavement construction; unfortunately, MacAdam is bitumen-rich and labor-intensive, which probably makes it unlikely to be constructed. The following suggestions are offered with regard to utility patching:

1. Consider charging a utility-cut fee to provide funds for later repair of distressed utility patches. This approach has been implemented in some municipalities in North America with significant success – it is much simpler to implement than to try to attempt to predict the future damage of a utility cut to the pavement structure. A reference on the subject is provided below.[1]
2. For deep trenches, evaluate the feasibility of employing controlled low strength materials (CLSM), also known as "flowable fill." This may not apply to every situation, however, and care must be taken to avoid overly strong material which is difficult to excavate, and to provide permeability properties that are similar to the surrounding material (this can be done through mix design and specifications.) In addition, CLSM may behave differently than surrounding pavement when subjected to frost; the state of New Hampshire has studied this and found that

[1] http://www.cityofpaloalto.org/cityagenda/publish/cmrs/2384.pdf

CLSM is not frost-susceptible, but the surrounding pavement is, thus introducing the potential for differential settlement. In order to avoid this scenario, limits can be placed on the minimum depth from the surface to the top of CLSM, approximating the depth of frost protection (at least 60% of frost protection depth.) CLSM can work particularly well with rigid (concrete) pavement.

List of Potential Innovative Treatments For Consideration

The following list (presented as Table 1) is by no means complete. The City is encouraged to leverage the experience of regional peers through participation in the Midwest Pavement Preservation Partnership and other regional and state organizations in order to exchange information and pool together resources for product evaluation. For more information on this partnership of state, regional, and local agencies please visit the National Center for Pavement Preservation website at http://www.pavementpreservation.org.

Treatment	Pavement Type to which it applies	Treatment Category	Benefits	Concerns
Joint cleaning and sealing	Rigid	Preservation	Prevention of water infiltration and subsequent loss of support	None
Diamond grinding	Rigid	Preservation; Rehabilitation if used in conjunction with CPR (Concrete Pavement Restoration)	Eliminate faulting, roughness due to warping and curling, improve finish after CPR	Economic if project is sufficiently large; portruding utility features such as manholes, etc.
Slab-jacking	Rigid/ Composite	Rehabilitation	Restore support to depressed slabs; there are many innovative products (I only know of Uretek as one of them)	Cost; may not be appropriate for all situations
Concrete Rubblization	Rigid	Replacement/ Reconstruction	Creation of strong base on	Increases elevation of new pavement – may require

Treatment	Pavement Type to which it applies	Treatment Category	Benefits	Concerns
			which to place a new pavement	additional work (such as removal of material at edges, etc.) to accommodate this; potential disruption to property owners through vibration, etc.; adequate drainage must be provided and special attention to permeability of overlying pavement must be paid.
Microsurfacing	Flexible/ Macadam/ Composite	Preservation	Protects pavement surface from effects of environment; increases skid resistance	Overlap between paving passes must be avoided (to prevent small "mound" from forming at overlap); crack sealing should be done prior to microsurfacing; mix design must be compatible with aggregates
Ultra-thin Hot-Mix Asphalt (4.75mm mix, Novachip)	Flexible/Macadam/Composite	Preservation/Band-aid	Protects underlying surface; can be used to reduce roughness to a certain degree; can provide some serviceability to poor pavements if accompanied by patching	Delamination; tack coat must account for this and/or a polymerized asphalt can be used as binder. Cost
Fog seal	Flexible/Macadam/Composite	Preservation	Provides some protection for surface; inexpensive	Some loss of friction initially
Rubberized Chip Seal	Flexible/Macadam/Composite	Preservation/Band-Aid	Outstanding surface protection and sealing	Gradation selection and aggregate pre-coating are essential, as are construction

Treatment	Pavement Type to which it applies	Treatment Category	Benefits	Concerns
			ability; long life versus conventional chip seals.	techniques and inspection; although loose material is much less than conventional chip seals this may still be a concern in some residential streets.
Hot-in-place recycling	Flexible/Macadam/Composite	Preservation	Removal of surface cracks; surface rejuvenation	Construction techniques, gradation control and rejuvenation dosage are essential to achieving performance.
Full-depth reclamation	Flexible/Macadam	Replacement/ Reconstruction	Economical reconstruction with high recycled content, typically 100%	Increase in elevation if some material is not removed; granular portion must be at least 50% of resulting base layer; some coarse aggregate may have to be added to increase stability. Overlying bound layers must be sufficiently thick to prevent structural failure