WHAT A BRIDGE MANAGEMENT SYSTEM CAN DO FOR A LARGE CITY

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ABSTRACT

The benefits derived through the implementation of a Bridge Management System (BMS) at the state transportation agency level are well documented. Little attention has been given, however, to the use of a BMS at the local agency level. Local agencies face many of the same challenges as state agencies regarding allocation of scarce resources such as dollars, labor and equipment, to address the needs of an aging infrastructure. Local agencies also must deal with the reality of maintaining this infrastructure to meet the needs of the local population. BMSs, as they are currently envisioned, are principally planning and programming tools. Enhancements must be made to BMSs to allow bridge design and maintenance engineers at the local level to utilize all the capabilities of the database to effectively management and respond to the needs of the infrastructure.

INTRODUCTION

The City of Chicago's Department of Transportation (CDOT) is unique among local agencies responsible for the management and maintenance of bridge infrastructure. With fifty bridges, CDOT manages and maintains the largest movable bridge system in the world. It also has inspection, maintenance and capital planning responsibility for thirty-two (32) fixed spans over water, 107 highway overpasses and thirty-seven (37) pedestrian bridges and tunnels. The total replacement value of its bridge infrastructure is estimated at over $2.6 billion dollars. Eight of its structures are classified as fracture critical and half of its bridge inventory is over 50 years old. CDOT also is unique in that it directly establishes and manages its capital program for the State of Illinois. Between eight to ten million dollars for maintenance and 25 million dollars for capital rehabilitation and replacement are spent annually by CDOT on its bridge infrastructure. Annual funding needs, however, are between 60 and 80 million dollars.

Maintenance monies are derived principally from Motor Fuel Tax and City backed bonds. Capital rehabilitation and replacement monies come from the federal government through the state. Contracts for all design and construction work are managed, bid and awarded by the city with approval from state and federal agencies.

CDOT performs biannual inspections of its bridge infrastructure and yearly detailed inspections of all fracture critical structures. These inspections serve as the principal source of information regarding the current condition of the bridges. Inspections are performed following the provisions of the Federal Highway Administration's (FHWA) Bridge Training Manual 90. Standard Illinois Department of Transportation (IDOT) forms are completed for each bridge inspected. These forms comply with the FHWA's "Recording and Coding Guide for the Structure Inventory and Appraisal of the Nations's Bridges" and provide data to support the requirements of the National Bridge Inventory (NBI). These inspections serve as the basis for the development of the City's Capital Program.

The size, age and complexity of this infrastructure pose particular problems in managing the data necessary to effectively prioritize maintenance repairs and capital rehabilitations and replacements. The standardized state and federal inspection forms do not capture all the information pertinent to CDOT's particular infrastructure. For example, no data are collected on the City's movable bridge electrical and mechanical systems. The inspection data collected also quickly looses its value due to the ongoing nature of maintenance repairs and capital projects. Since the data are not dynamic, limited by the frequency of inspections and the volume of this data is large, management's ability to quickly respond to changes in funding or assess the impact of capital deferrals is severely impaired.

Starting last year, CDOT began completing detailed assessment and defect inspection for each bridge rather than rely solely on the "free form" comment format used by the state inspection form to identify defects. A consistent identification and coding taxomony was developed which is used to locate critical defects and conditions for a structure on a span by span basis. This methodology allows the replication of the inspection for quality control and dispatch of repair crews to a given location. This detailed inspection forms the principal basis for the development of the City's bridge maintenance program.

A BRIDGE MANAGEMENT SYSTEM FOR A LOCAL AGENCY

For most local agencies, the small size of the bridge infrastructure means that decisions regarding planning and funding can be done without the aid of sophisticated analysis tools. Managing that infrastructure does not pose significant data management requirements. Immediate access to that data is of less important to a small local agency than it is to the state. Thus, information needs for a small local agency can be addressed on an "as needed" basis.

A large local agency, such as CDOT, that manages and implements its own capital program, shares many of the same information needs as a state agency. Due to its infrastructure's age, size, and complexity, the ready access to that information is of equal or greater importance than that of a state agency. Issues of resource allocation, current condition and future capital needs are as important to such local agencies as they are to state agencies. The challenges posed by limited and changed funding levels have even greater implications at the local level than they do at the state level. Managers at the local agency level require the same "what if" capabilities to effectively assess the impact of deferred capital investment.

To address this information need, the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, mandated that all state transportation agencies implement Infrastructure Management Systems (IMS) by the start of federal fiscal year 1995 (*1*). Failure to implement such systems by that date may result in withholding of up to ten (10) percent of federal funding apportioned through the ISTEA. Local agencies are generally exempt from the requirement to implement such systems. They are, however, required to provide input and data support to the IMS process through Metropolitan Planning Organizations (MPO). BMSs are one element of the IMS.

> "The (BMS) system itself consists of a database and an analysis capability that enable an agency to efficiently evaluate bridge needs, develop recommendations, and assess the near and long term impacts of bridge policies and alternative courses of action." (*1*)

As with the IMS, local agencies are not required to implement such systems, however participation in the state BMS is required and the data collected must be consistent with state BMS requirements.

The proposed federal requirements for a BMS reference the American Association of State Highway and Transportation Officials (AASHTO) Guidelines for Bridge Management Systems as the minimum standards for system design and implementation. The AASHTO Guidelines establish twelve minimum requirements for the BMS software (*2*). Central to this software is a database that serves as the repository for the inspection data used by the BMS. The remaining elements provide modeling capabilities that are principally used to forecast, plan and assess the impacts of funding on bridge capital programs.

BMS Applications at the Local Level

By virtue of its current design, the BMS has significantly greater application to needs of the City Planner and Program Administrator than the Chief Design or Maintenance Engineer. The optimization models used by the BMS seem to lend themselves to the occasional level of use demanded by the Planner and Administrator. The focus of the elements identified in the AASHTO Guidelines for a BMS support the programming aspects of bridge management over the engineering and maintenance aspects of the task. These current limitations should not, however, be construed as limiting the BMS's usefulness at the local agency level. The BMS can provide a context for the establishment or increase of local funding levels to support maintenance of the bridge infrastructure through enhanced justifications. The effects of deferred maintenance, such as for painting, can be easily seen through the modeling capability of the BMS. Based upon the optimization scenarios provided by the BMS, better justification can be developed to obtain an increased share of local level dollars for bridges.

For a local agency that plans and maintains its own capital program, the ability to evaluate changes in funding levels is essential. The BMS provides the data that are necessary for the planner and programmer to shift priorities to meet program changes. Adjustments in ongoing programs due to cost overruns or underruns could be quickly assessed with the BMS's cost models. The development of local programs for submittal to the state and federal level would also be expedited with the BMS.

The methodology required to establish the BMS impose certain disciplines on the local agency that might not otherwise be present. Engineers and planners must develop, evaluate and assess cost and deterioration data that are to be input into the BMS. This forces a conscience review by these decision makers of known factors that affect bridge life and life cycle costs. Previously assumed truths regarding pricing and durability can be tested against actual conditions using the models. The BMS database provides a convenient repository for the data collected on the biannual bridge inspections. These data can be used to prepare and transmit the information needed by state and federal agencies to update the NBI. The more rigid data collection methodology provides a means to insure the easier replication of inspections. Reproducibility of inspections is currently limited due to the reporting methodology allowed by the federal and state inspection forms. Follow-up inspections and quality assurance checks are of limited value since much of this data is in a form that is not easily retrieved or replicated in the field. The more detailed information required by the BMS allows the easy location of a particular defect in the field. Through its links with the IMS, the BMS forces local agencies to broaden their planning horizons. The need to interface between other infrastructure projects becomes a reality with the BMS. Greater efficiency can be gained through the "packaging" of like projects or adjacent projects. Greater coordination for construction would also minimize the impact on traffic.

Limitations of the BMS to Local Agencies

With 226 bridges, CDOT has a large bridge infrastructure compared with most local agencies. Within that infrastructure, there are a variety of bridge types and construction details. The probabilistic models used to forecast life expectancy, repair/rehabilitation costs and project types benefit from the large number of similar structure types and constructions typically found at the state and federal level. It is expected that the BMS models would have some limitations at the local level based upon the available population of data for a particular bridge type and construction details. Although these forecasting models may be adequate to establish funding for a particular type of repair or rehabilitation program at the state level, these predictions may not be readily transferred to specific projects at the local agency level.

To be a truly effective tool at the local level, the BMS should explore greater use of the database capabilities as a management tool for engineers. The BMS must provide more support to the local agency's Chief Bridge Maintenance or Design Engineer. Many potential enhancements identified as the short range goals in the AASHTO BMS Guidelines have immediate use to the local agency engineer (*2*). These enhancements include:

- Work order capability to dispatch repair crews. This system should be fully linked to database and note when capital programs are pending. This information can be used to tailor repairs to meet specific funding objectives and insure efficient use of limited resources. The system also should provide immediate update of the database. This capability presupposes a much more rigid taxonomy for the identification and location of bridge elements and components. The inspection system employed by CDOT has the rudimentary underpinning of such a system. Design and maintenance engineers must have the ability to accurately duplicate an inspection and quickly locate existing problems. More efficient inspections can be realized through the verification of existing conditions. With existing conditions quickly verified, the inspector can focus on the identification of new defects or conditions. A higher quality inspection is the result.
- Scheduling of inspections and monitoring of critical conditions. The system should produce summary level reports on current conditions that can be used to track critical bridge structures.
- Monitoring of permit loads to assess the effects of fatigue on structure and a means of identifying remaining life. For many local agencies, this poses one of the greatest challenges. Moving permit loads through a bridge system knowing the influence curve for a particular structure would greatly reduce the labor currently expended on such efforts. This capability also would benefit state agencies.
- The addition of other factors, not currently captured by the BMS, that may influence local agency project level decisions. Congestion mitigation, availability of alternate routes for detours, coordination with other projects and demographic considerations for allocation of programs, among other factors, must be evaluated in the preparation of local maintenance and capital programs particularly in large metropolitan areas. The BMS models should have the ability to be "tuned" to recognize these criteria.
- Expand the models to included movable bridge structures. The current NBI collects limited data on movable bridge structures. The electrical and mechanical systems of these bridges, in particular, represent potentially high capital investment requirements. More detailed information is required to effectively manage this infrastructure and assess the impacts of limited funding.

CONCLUSIONS

Local agencies need the ability to effectively allocate scarce resources of dollars, labor and equipment, to extend the useful life of its bridge infrastructure. Although capital plan forecasting is an element of CDOT's overall bridge program, the principal focus is in the day to day management of the bridge infrastructure to insure its continued serviceability. Local agencies must have the tools readily available to meet these needs. Large bridge infrastructure systems such as Chicago's could benefit directly from the implementation of a BMS outside the state agency level. Additional enhancements must be made to the proposed BMS format to insure its use by the widest number of users. The current BMS designs do not fully explore the potential uses of the database information as it applies to the needs of the Chief Bridge Design and Maintenance Engineer. The BMS models must also be sensitized to local needs and parameters, beyond those of cost and deterioration, to be truly effective management tools.

REFERENCES

1. "Management and Monitoring Systems; Proposed Rule," *Federal Register*, Volume 58, Number 39, U.S. Department of Transportation, Washington, D.C., March 2, 1993.
2. Hyman, William A. and Paul D. Thompson, *AASHTO Guidelines for Bridge Management Systems,* National Cooperative Highway Research Project No. 20-7, Task 46, Transportation Research Board, Washington, D.C., February 7, 1992, pp 10-13.