Management of Bridge Maintenance, Repair, and Rehabilitation—A City Perspective

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ABSTRACT

The management of bridge maintenance, repair, and rehabilitation functions is discussed from the perspective of a major metropolitan city. The management objectives of the city, and the data base and cost control systems that assist the city in effectively managing the growing responsibilities in these fields, are described. Further, information concerning how routine and scheduled bridge maintenance and repair, as well as scheduled bridge rehabilitation, is planned, coordinated, and administered is also discussed.

It is widely known that a large percentage of the 567,820 bridges in the United States are in urban areas, and an even larger percentage of these bridges are under local government jurisdictions. Of the 302,775 bridges under local government jurisdictions, 165,928, or more than 50 percent, are considered to be deficient according to FHWA standards. Therefore, bridge maintenance, repair, and rehabilitation has assumed a larger dimension in local government responsibilities. In this paper the discussion centers on how Minneapolis, Minnesota, a major metropolitan city, views and manages this responsibility.

MANAGEMENT OBJECTIVES

There are 399 bridges serving the transportation needs within the city of Minneapolis. The data in Table 1 indicate the number of different bridge groups and their average ages. Based on age and condition of these bridges, the management objectives of the city are as follows:

1. Pursuant to state statutes, conduct annual maintenance inspection of 260 bridges for which the city is responsible to ensure that all repair needs and normally predictable major bridge problems are identified;
2. To provide preventive maintenance for and maintain in safe condition 176 bridges, 38,000 linear feet of bridge approaches, pier protections of six major river crossings, and 10,000 linear feet of various types of embankments and retaining walls;
3. To ensure safety of pedestrians, control snow and ice on 154 bridges, 38,000 linear feet of bridge approaches, and 28 pedestrian bridges; and
4. To do necessary major bridge repair and rehabilitation work, including work under county and state agreements.

TABLE 1 Bridge Groups and Average Age

	Bridge Group	No. of Bridges	Avg Age (years)
A	Interstate highway	70	14
B	Street over or under Interstate highway	74	17
C	River	13	55
D	Railroad	130	62
E	Creek	40	50
F	Miscellaneous	11	31
G	Pedestrian	28	17
H	Parkway	33	58
Total of C-H		255	53
Total		399	40

MANAGEMENT INFORMATION SYSTEMS

Bridge Structure Inventory and Inspection

The data in Tables 2 and 3 describe a broad range of valuable information available from the data base system. The bridge maintenance, repair, and rehabilitation or replacement decisions for the city are primarily based on the up-to-date information provided by this system. A library of more than 5,000 drawings on microfiche and periodic field measurements support and update the structure inventory.

The current formal bridge inspection program was instituted in 1971. The inspection team consists of two to four trained inspectors. A large variety of tools and equipment (such as sounding equipment, cameras, a snooper-truck, and boats) are used in the inspection process. A library of photographs, in chronological sequence, along with historical inspection records and scour studies around piers of river bridges are also maintained. When more frequent inspections are needed for some critically deficient bridges, inspections are conducted daily.

Every year structure inventory and inspection records are updated during winter months and communicated to the Minnesota Department of Transportation. The state's computer is used to maintain annual bridge structure inventory and inspection records. These records are then used to compute the FHWA's sufficiency ratings, and computer printouts are made available to the city.

Structural Capacity Ratings

Evaluation of current structural capacity of all bridges is completed at least once every 5 years. Inspection reports with current estimates of loss of sections are used for this purpose. Interim capacity ratings become necessary when accelerating deterioration or accident damage is reported in inspection reports.

Results of structural capacity ratings are promptly communicated to appropriate agencies or organizations and necessary load limit signs are posted. Typically, bridges are posted for gross weights of a truck (M-3) and truck and semitrailer combination (M-3S2). In some instances a combination of load limits and speed limits is used. The structural capacity information is updated as often as deemed necessary and promptly communicated to state and city enforcement agencies. Currently, 29 bridges

TABLE 2 Bridge Structure Inventory and Appraisal

Data Base--Part I: Section A

STRUCTURE INVENTORY AND TRAFFIC (SECTION A): (Dated_____; Updated_____

1. Structure Number_____; Built in_____; Remodeled in_____; Owner_____
2. Inventory Route_____; Over/Under_____; Location_____
3. Alternate Length_____; Impact on Travel Time_____min.;kmh (mph)_____
4. Lanes/R.R. Tracks (over)_____; (under)_____; One/Two Way_____
5. Av. Daily Traffic (ADT) on Bridge_____;Peak Hour Traffic_____;Year_____
6. Projected ADT_____; For Year_____; Heavy Commercial ADT_____
7. Design Load_____; Present Structural Capacity_____; Posted Load Limit_
8. Approach Width: Roadway_____; With Shoulder_____
9. Angle Skew_____; Is Structure Flared?____; Width: Max____; Min._____
10. Minimum Clearances: Vertical: Over_____; Under_____
    Horizontal: Over_____ (North/West);_____ (South/East)_____
    Under_____ (North/West);_____ (South/East)_____
11. Navigation Control: Yes/No; Vertical_____; Horizontal_____
12. Structure Type: Main Span_____; Approach Spans_____
13. Number of Spans: Main_____; Approach_____
14. Structure Length: Total_____; Max. Span._____; Approach Spans_____
15. Widths: Roadway (curb to curb)_____; Deck (out to out)_____
    Sidewalks:_____ (North/West)_____ (South/East)_____
16. Wearing Course and Overburden: Type(s)_____; Thickness(es)_____
17. Guardrail: Type__;__ Length; Other Railings: Type_____; Length_____
18. Utilities Carried, Location_____
19. Joints on the Bridge: Type_____;Length_____
20. Lighting System_____
21. Painted in_____; Type of Paint_____
22. Material Inventory: Roadway_____; Sidewalk_____
    Substructure_____; Superstructure_____
23. Other Features (such as safety lights):_____

Data Base--Part I: Sections B and C

STRUCTURE INSPECTION AND APPRAISAL (SECTION B): (Dated_____)

1. Deck: Overall Condition_____
   Type and Extent of Deterioration_____
   Repairs Needed and When_____
2. Superstructure: Overall Condition_____
   (Other than Deck) Type and Extent of Deterioration_____
   Repairs Needed and When_____
3. Substructure: Overall Condition_____
   Type and Extent of Deterioration_____
   Repairs Needed and When_____
4. Safety Considerations: Unsafe or Hazardous Conditions_____
   (Width, alignment, load-limits, steep grades, railings, clearances, etc.)
5. Serviceability: Drainage_____
   Rideability (Roughness Coefficient)_____
   Lighting_____
6. Condition of Paint_____
7. Estimate of Remaining Life: Without (with) major repairs____(____)Years
8. Description and Estimated Cost of Major Repairs Needed and When_____

STRUCTURAL CAPACITY AND FUNCTIONAL ADEQUACY (SECTION C): (Dated_____)

1. Load Carrying Capacity_____
   (Based on: Current Legal Loads_____, Estimate of Deterioration_____
2. Minimum Clearances: Vertical_____; Horizontal_____
3. Adequacy for Present and Projected Traffic_____
4. Waterway Adequacy and Protection (e.g., Pier or Scour Protection)_____
5. Limits for Special Permit Loads____; Wheel-Load Configuration Used_____

Data Base--Part II

MAINTENANCE HISTORY AND PROJECTED FUTURE NEEDS (SECTION D): (DATED_____)

1. Chronology and a Brief Description of Major Repairs Done:_____
   (When, what, at what cost and who made them, improvement in life expectancy)_____
2. Brief Description of Minor Repairs in the Past Five Years_____
3. Projected Future Maintenance Needs: (e.g., New Overlay)_____

ENVIRONMENTAL AND OTHER FACTORS (SECTION E): (Dated_____)

1. Aesthetical Considerations (e.g., Paint, etc.)_____
2. Developmental Plans and Projected Needs of the Area Served_____

TABLE 3 Typical Bridge Inspection Data Sheet

CITY OF MINNEAPOLIS

Urgent_____

INSPECTION

Bridges and Related Structures

1. IDENTIFICATION: Bridge No._____ Mn/DOT No._____ Apr._____

Location _____

Posted Limit_____ Inspected By _____ Date_____

2. CONDITION & SUGGESTED IMPROVEMENT: RATING

Railing_____

Curb_____

Roadway_____

Subsurface_____

Sidewalk_____

Subsurface_____

Stringers_____

_____

_____

( )_____

_____

Expansion Devices_____

Piers_____

_____

_____

_____

Abutments_____

_____

_____

Walls_____

_____

Warning Lights_____

Lighting_____

Other_____

3. GENERAL CONDITION & REMARKS: _____

_____

4. IMPROVEMENTS & REPAIRS: _____

Estimated Cost_____ Date Needed_____

5. PLANS MADE OR OWNER NOTIFIED: _____ DATE_____

6. REPAIRS MADE: _____ DATE_____

7. CONDITION CODES: DECK_____ Superstructure_____ Substructure_____

are posted for load limits and 4 bridges are closed to vehicular traffic.

Cost-Control System

In 1980 a new financial and accounting information system was instituted with the capability of providing up-to-date cost records for any work being done on any one of the bridges. This computer-based system uses location and activity codes. The coding system is given in Tables 4 and 5. Each bridge is identified with letters JC followed by a four-digit number. Letters PC instead of JC identify approaches for that bridge. The first two digits of the bridge number identify the bridge group it belongs to and the route system it is on. Other locations are identified by two zeros and two digits following the letters PC.

The city does all of its bridge maintenance, repair, and (some) rehabilitation work using its own forces. Therefore, the activity codes are organized in such a way that each foreman can select appropriate codes while reporting daily activities of in-

TABLE 4 Cost-Control System: Location Codes

Bridge numbers	JC 0001-JC 9999
Bridge approaches Special locations	PC 0001-PC 9999

Bridge approaches first digit (after letters PC): zero

PC 0001:	Bridge yard and plant
PC 0002:	Bridge division—boat dock and building
PC 0003:	Harbor lights—river bridges
PC 0004:	Mississippi River bridges (flood control)
PC 0005:	Minnehaha Creek bridges (flood control)
PC 0006:	Shingle Creek bridges (flood control)
PC 0007:	Bassetts Creek bridges (flood control)
PC 0008:	All bridges
PC 0009:	Bridge building expansion
PC 0010:	Major equipment—snooper
PC 0011:	Major equipment—pontoon boats
PC 0012:	Major equipment—pusher (tow boat) and/or barge
PC 0013-PC 0020:	Bridge—miscellaneous
PC 0021:	City Hall—bridge: office and administration
PC 0022:	Bridge yard: office and administration

dividual crews. Answers to simple questions such as "What activity?", "In which area?", and "Who did it?" help the foreman or supervisor select appropriate activity codes.

All costs related to the activity are also reported and processed by the computer on a daily basis. Therefore, this system has the capability of producing reports (on demand or periodically) of costs of each activity, budget line-item expenditures and balances (year to date), and revenues. The system serves the city as an effective tool in monitoring and controlling costs of all bridge-related activities.

BRIDGE MAINTENANCE AND REPAIR

Routine Maintenance and Repair

Routine maintenance and repair is an ongoing activity to provide preventive maintenance for and maintaining in safe condition 176 bridges, 38,000 linear feet of bridge approaches, pier protections of six major river crossings, and 10,000 linear feet of various types of embankments and walls. This activity is funded totally by general revenue and is conducted with permanent and day-labor staff.

During the spring, summer, and fall bridge crews are busy with the following types of activities:

1. Washing steel grid deck bridges;
2. Cleaning joints, beam seats, catch basins, and drains;
3. Removing sand, salt, and debris from bridge decks;
4. Welding and other structural steel repair;
5. Patch, repair, and seal spalled, cracked, and deteriorated concrete;
6. Repair accident and fire damage, emergency repairs;
7. Remove branches and debris from around piers in river and creeks; and
8. Erosion control.

During the winter months crews are kept busy in snow and ice control on 154 bridges, 38,000 linear feet of bridge approaches, and 28 pedestrian bridges. Repairs of an emergency nature and of accident damage are also conducted during this period. This activity is fully funded by general revenue and is conducted with permanent and day-labor staff.

Scheduled Major Maintenance and Repair

Scheduled major maintenance and repair is more of a nonroutine type and is based on reports of formal bridge inspections. As the annual formal inspections conclude, inspection reports and maintenance history for each bridge are reviewed. When necessary, another inspection by a senior supervisory-level engineer is scheduled, especially in cases of accelerated deterioration or serious accident damage. At this stage maintenance and repair needs of each bridge are evaluated. An annual needs statement is then prepared. Typically, the needs statement indicates type, extent, preliminary cost estimates, and urgency of maintenance or repairs needed for each bridge.

The needs statement is then reviewed with other relevant information such as the current FHWA sufficiency rating and importance of the bridge in the present and projected overall transportation needs of the area. The maintenance and repair needs are then assigned on a priority basis according to their urgency and by matching the cost estimates with pro-

TABLE 5 Cost-Control System: Activity Codes

What Activity?	In Which Area?	Who?
A. New work or replacement	A. Roadway	A. Maintenance
B. Maintenance and repair	B. Sidewalk and/or curb	B. Carpenter
C. Concrete patch	C. Railings and fences	C. Ironwork
D. Asphalt patch	D. Beams or girders	D. Cement finisher
E. Maintenance cleaning	E. Abutments	E. Painter
F. Grass cutting and weed control	F. Columns or pier bents	F. Shop repair
G. Flood control	G. Walls	G. Stock help
H. Snow and ice control	H. Embankments	H. Other
J. Routine bridge inspection	J. Miscellaneous—structural	J. Accounting staff
K. Formal bridge inspection	K. Combination of above	K. Supervisory staff
M. Soundings	M. Mowers and grass cutting equipment	M. General foreman
N. Project engineering	N. Snow and ice equipment	N. Engineers
P. Construction engineering	P. Other equipment	P. Engineering contract
Q. Structural capacity rating	Q. Tool storage boxes, snow trailers, and wagons	
R. Administration and support services	R. Salaries	
T. Administration—office expenses	T. Additives—vacation, holiday, sick, and other leave	
X. Rental	X. Additives—workman's compensation, employee injury expenses, unemployment compensation, severence pay	
V. Store—supplies	V. Unallocated	
W. Capital outlay		

jected availability of general revenue funds for the following year. Individual major bridge maintenance and repair is then scheduled as the bridge maintenance and repair budget for the following year is finalized. As a general rule, the FHWA sufficiency rating for those bridges on which major maintenance and repair is scheduled would range between ±50 to 80.

Typical major bridge maintenance and repair activities are as follows

1. Repair or replacement of steel stringers, beams, or steel grid panels;
2. Repair of concrete beams, columns, abutments, and walls;
3. Repair or replacement of pier protections;
4. Replacement of expansion devices;
5. Extensive repair of masonry;
6. Construction of walls for erosion protection;
7. Sidewalk and deck slab repairs and overlays;
8. Painting of structural steel; and
9. Extraordinary maintenance and repair for the state or county.

BRIDGE REHABILITATION

Rehabilitation or Replacement Decision Making

Realities of fiscal constraints are such that the city can neither think of replacing all of the aging bridges nor reasonably justify replacement options in all cases. In 1980 a Bridge Task Force was created to evaluate the bridge needs of the city and to recommend a 5-year capital improvements program. As a part of this process, bridges a with sufficiency rating between 0 and 80 are screened annually and possible candidates for rehabilitation, replacement, or rehabilitation and replacement are identified and assigned priorities based on structural condition, safety, and overall transportation needs.

Bridges that are candidates for rehabilitation or rehabilitation and replacement within the next 5-year period become the subject of an in-depth investigation. All components of the superstructure and substructure are investigated by reputed materials engineering consultants for material properties, deterioration, and their available structural capacity. A decision is then made, based on recommendations resulting from this in-depth investigation, as to whether any part or all of the bridge structure can be rehabilitated and modified to meet the future overall transportation needs of the city. Bridges that are to be scheduled for rehabilitation and replacement within the next 5-year program are recommended to the City Council as a part of the capital improvements program (CIP). Funding for this program is generally sought from municipal or county state aid, state bridge bond, or federal SBR or Resurfacing, Restoration, and Rehabilitation funds.

Scheduled Bridge Rehabilitation

Plans for scheduled rehabilitation of a bridge are either drawn in-house or by consulting engineers retained by the city. Similarly, the rehabilitation work, depending on its magnitude and complexity, is either done by using city forces or contractors. In either case, the city engineering staff supervises the construction activity.

CONCLUSION

The magnitude of problems related to maintenance, repair, and rehabilitation of bridges within the city of Minneapolis has been on the increase. However, efforts through effective management are being made to contain and limit these problems. Because of the involvement of many agencies, and as many as five railroads, delays can complicate execution of the city's policies. Therefore, cooperation among different agencies and groups that represent a variety of interests governs the success of the management efforts of the city.

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