IMPLEMENTATION OF A BRIDGE MANAGEMENT SYSTEM IN THE MUNICIPAL ENVIRONMENT

Nordengen, P.A.[1], Roux, M.P.[2]

[1]CSIR Built Environment, P O Box 395, Pretoria, South Africa. E-mail pnordengen@csir.co.za
[2]CSIR Built Environment, P O Box 395, Pretoria, South Africa. E-mail mproux@csir.co.za

ABSTRACT

Since the 1994 elections, municipalities have been focusing on the delivery of basic services i.e. roads, drainage, water, sanitation, electricity and health services. These newly constructed infrastructure assets, as well as those constructed prior to 1994 and still in service, present a huge responsibility for municipalities to operate and maintain. There is strong evidence insufficient attention has been paid by the majority of municipalities to the on-going commitments they have incurred to operate and maintain their infrastructure assets. The effect will be that these assets will deteriorate and become out-of-service well before the end of their design life. One type of asset for which municipalities are responsible is structures, which includes bridges and culverts. During the past few decades, little attention has been given by many municipalities to the overall condition of structures in general, and to a large extent structure rehabilitation projects that were commissioned, were done on an *ad hoc* basis.

This paper describes the implementation of a bridge management system (BMS) in the municipal environment, with specific reference to the City of Cape Town, the Johannesburg Roads Agency and the Nelson Mandela Metropolitan Municipality. Implementation takes place in three phases. During the first phase, the standard BMS is customised to meet the specific needs of the client municipality and includes the integration of the BMS with the municipality's Asset Management Information System. The second phase involves the appointment of structural engineers to carry out visual assessments using a defects-based rating system in order to determine the priority ranking of all inspected structures. The third phase involves the validation of assessments and prioritisation of structures in terms of maintenance needs and selection of suitable rehabilitation projects.

1 INTRODUCTION

All modern economies are underpinned by a vast infrastructure of roads and other transport systems, water supply, waste disposal, energy, telecommunications, recreational networks and property. These infrastructure assets constitute a major investment over many generations, made in the hope that benefits will accrue through increased productivity, improved living conditions and greater prosperity (International Infrastructure Management Manual (IIMM) 2006).

In South Africa, since the 1994 elections, the three tiers of government have been focusing on the delivery of basic services, that is, roads, drainage, water, sanitation, electricity, and health services and an immense amount of money has been invested in engineering services infrastructure. The replacement cost of services infrastructure constructed prior to 1994 and still in service is thought to be of an even larger order of magnitude than the replacement cost of that constructed since 1994 (Wall 2005).

Infrastructure needs cannot be met through investment in infrastructure creation only, without recognising the long-term life-cycle costs associated with the ongoing operations, maintenance and renewal of infrastructure. Infrastructure management issues, and in particular the techniques that aid responsible infrastructure management are of vital importance.

In recent years government policy has focused on balancing the growing short term need to deliver new infrastructure with the need to make decisions that will stand the test of times. Though broad legislative themes support the notion of sustainable asset management practices, no detailed regulations exist to drive this process. However, a range of initiatives point towards a groundswell of support for the formal adoption of infrastructure asset management practices (IIMM 2006).

In 2004, National Treasury issued an Asset Management Guideline that introduced the concept of asset management and provided broad guidelines for the public sector. In August 2005 Cabinet issued a statement approving a government-wide Immovable Asset Management Policy to ensure uniform, efficient, effective and accountable asset management of public assets practices (IIMM 2006). The Government Immovable Asset Management Bill was published on 14 October 2005. This Bill seeks to introduce measures to ensure a uniform framework for the management of immovable assets that are held and used by a national or a provincial department and its coordination with the service delivery objectives of a national or a provincial department.

At local government level, the Municipal Finance Management Act (MFMA) specifies the general requirements that all revenue, expenditure, assets and liabilities of municipalities are to be managed economically, efficiently, and effectively. The Municipal Systems Act (MSA) requires all municipalities to prepare, adopt and implement Integrated Development Plans (IDPs). An IDP is the principal municipal strategic planning instrument, but aspects such as service delivery performance, lifecycle planning, long term vision, risk management and asset management improvements are not adequately and holistically dealt with by either the IDP or sector plans, where the focus of the latter plans is mostly on new development (IIMM 2006).

There are no specific legislative requirements for the development of asset management plans, but there have been significant local government asset management initiatives recently. These include the development of the latest edition of the International Infrastructure Management Manual. The South African Edition 2006 of this manual was recently launched. Accounting regulations also require local authorities to have some form of asset management. The Generally Accepted Municipal Accounting Practice (GAMAP) Standard 17 provides guidelines for the accounting treatment of property, plant and equipment (PPE). It defines an infrastructure asset as forming part of a stationary network of similar assets and prescribes the methods for immovable asset valuation and lifecycle accounting treatment (IIMM 2006).

A 2003/2004 CSIR survey found that a few municipalities have world-class practice in respect of many of the aspects of asset management (such as knowledge of assets, demand analysis, asset creation and disposal, asset utilisation, and operation and maintenance), although they might be lacking in such as strategic planning, asset accounting, and planning for and making financial provision for renewal and upgrading of infrastructure. On the other hand, many municipalities do not even have the basic processes for asset management in place, and many of them demonstrate gross shortfalls in management policies and practices. Most municipalities find themselves between these two extremes, showing the entire range of management capacity and competency levels.

One type of asset for which municipalities are responsible is structures, which includes bridges and culverts. During the past few decades, little attention has been given by many municipalities to the overall condition of structures in general, and to a large extent structure rehabilitation projects that were commissioned, were done on an *ad hoc* basis.

Important legal requirements relating to the inspection and maintenance of structures are included in the Construction Regulations, 2003, published under the Occupational Health and Safety Act, 1993 (Act 85 of 1993). In terms of these regulations, owners of structures are compelled to ensure that inspections of structures upon completion are carried out periodically by competent persons in order to render the structures safe for continued use. Such inspections must be carried out at least once every six months for the first two years and thereafter yearly and records of such inspections must be kept and made available to an inspector upon request (Regulation 9(4)). Owners of structures must further ensure that the structures upon completion are maintained in such a manner that the structures remain safe for continued use. Such maintenance records must be kept and made available to an inspector upon request (Regulation 9(5)).

2 OVERVIEW OF BMS

2.1 General

As in the case of most asset management systems in general and bridge management systems in particular, the STRUMAN BMS consists of an Inventory module, Inspection module, Condition module and Budget module. Its main distinction is perhaps in the Inspection module where the focus is on the observed defects of the various bridge or culvert elements rather than the overall condition of each element.

2.2 Inventory module

The first step in the implementation of a BMS database is to compile the bridge inventory which consists of a record of all bridges in the network with comprehensive details of the type of bridge, construction materials, major dimensions, clearances, etc. This information is obtained from "as-built" plans and confirmed and/or measured in the field. Details such as loading and hydraulic data, where not available on drawings, are obtained from the design engineers if possible. Depending on the availability of drawings, the collection of inventory data can be a costly exercise.

2.3 Inspection module

Each structure must be appraised at a network level with respect to its condition of serviceability and safety. The inspector completes standard inspection forms listing all the elements of a bridge structure with all the common defects normally encountered. Bridges have been subdivided into 21 items as follows:

1. Approach embankment
2. Guardrail
3. Waterway
4. Approach embankment protection works
5. Abutment foundations
6. Abutments
7. Wing/retaining walls
8. Surfacing/ballast
9. Superstructure drainage
10. Kerbs/sidewalks
11. Parapet/handrail
12. Pier protection works
13. Pier foundations
14. Piers & columns
15. Bearings
16. Support drainage
17. Expansion joints
18. Longitudinal members (deck)
19. Transverse members (deck)
20. Deck slab
21. Miscellaneous items

The appraisal is carried out regularly for all bridges but may be required more frequently for steel bridges and bridges subject to foundation settlements or flooding. Principal inspections are carried out every three to five years, depending on the availability of funds. Monitoring inspections, to assess the deterioration of certain defects specified during principal inspections, as well as after major disasters such as floods, are carried out more frequently. The deterioration of structures is monitored by means of both principal and monitoring inspections.

2.4 Condition module

The condition module is used to prioritise the bridges in the system based on the most recent inspection data. The overall priority index is based on the priority and functional indices. The functional index gives an indication of the strategic importance of the bridge in the network and is calculated from various parameters in the inventory module. These include class of road or railway line, detour length, traffic volume, width between kerbs, type of structure and profitability of line (in the case of rail structures). The parameters used for the functional index are user-defined and are given greater or lesser relative importance by user-defined weighting factors.

The priority index is based on the condition rating of the structure and is calculated from the D (Degree), E (Extent) and R (Relevancy) rating of the identified defects on each of the 21 predefined inspection items. More importance can be given to certain items such as deck slab, longitudinal members and piers as opposed to items such as guardrail and surfacing by means of user-defined weighting factors.

During an inspection, sub-items are inspected and rated individually, such as piers and deck spans. However, individual columns forming a single pier, or longitudinal members on one span, are considered as one sub-item.

A distinction is made between the condition index and priority index. The condition index gives an indication of the condition of the structure as a whole, taking into account each item and sub-item. For example, all nine piers (eight in good condition and one in poor condition) of a ten span bridge are included in the calculation. The priority index, on the other hand, which is used to determine the bridge ranking, only takes into account the worst rating of the sub-items of an item such as piers. Thus in the above example, only the one pier in poor condition would be used in the priority ranking calculation, and the piers in good condition are ignored.

2.5 Budget module

The main purpose of the budget module is to assist the bridge manager in allocating identified repair work into different budget years. The estimated quantities for repair that are done during inspections are used as a basis for determining budgets for the repair of each structure. Repairs are allocated to the “Current year”, “Year 5” or “Year 10” based on the urgency rating (U) allocated by the inspector. During an optimisation procedure, the estimated cost of repair for each defect is compared with the relevancy of the defect to determine a benefit-cost ratio. In the case of limited budgets, maximum benefits can be achieved by first repairing items with the greatest reduction in risk to the road user and the lowest cost. In addition there is a facility whereby the bridge manager can overwrite the optimisation procedure by manually assigning selected bridges or types of repair work into a chosen budget year. The budget can then be re-optimised with the given constraints.

2.6 Maintenance module

In order to complete the cycle of the BMS, all maintenance activities that have been successfully completed are required to be entered into the system. This includes information such as actual quantity of work done, contractor, date, actual cost and any other significant comments. The system assumes that the defect no longer exists on the relevant item once the maintenance work has been indicated as complete.

2.7 Additional modules

A Photo Module is included where predefined inventory photos and photos of each defect are recorded. A Map Viewing Module is available for viewing bridges and culverts information and condition on a GIS map. A Seismic Module is also available.

3 INSPECTION RATING PROCEDURE

Perhaps the most important element of a bridge management system is the inspection rating or condition assessment procedure. The ability to capture accurately on paper the condition of the structure in terms of the structural integrity and the safety of the user has a major impact on the quality of the system outputs and ultimately determines the success of a BMS.

The method chosen to inspect bridges is very important in that it is the only tangible record that can be used for rating of bridges and for the repair budget predictions. Simple and more precise inspections result in more accurate analyses. The essence of a bridge inspection is to identify the defects on a bridge and their relative importance so that they may be prioritised and the available funds allocated efficiently for their repair. It is thus important to rate the degree of each defect (how bad is the defect) and the extent to which the defects exist on the respective inspection item (how common is it). However the most important purpose of the rating is to identify the consequences of the defect with regards the safety and serviceability of the bridge. This forces the inspector not just to give a visual rating of the defect but to look at the defect from a global point of view and to understand its influence on the structural integrity of the bridge. Because of the complexity of a bridge this last rating is very important; two defects that look the same may have significantly different influences on the bridge when one considers the safety of the motorist.

The rating system which has been used in the approach to condition assessments is referred to as a DERU rating system and has the following components:

- D represents the degree or severity of the defect
- E is the extent of the defect on the item under consideration
- R is the relevancy of the defect. This rating considers the consequences of the current status of the defect with regard to the serviceability of the bridge and the safety of the user (pedestrian, cyclist, motorist, and passenger).
- U is the urgency to carry out the remedial work to repair the defect. This rating considers possible future events that could adversely affect the defect, and provides a procedure for applying time limits on the repair requirements.

Together with the urgency rating, the inspector is required to identify the remedial work activity (and estimated quantity) that must be carried out to repair the defect. The repair activity is selected from a standard list that is different for each bridge item. Activities include, for example, repair spalled concrete (all concrete items), backfill erosion/scour damage (approach embankment), remove sand, debris and vegetation (surfacing) and reinstate expansion gap between deck and abutment (abutments). Each of the repair activities has a unit rate that is used in the budget module to determine an estimated budget for the repair of the structure.

The rating is essentially a four point system (1 to 4), with values of zero, X, U and R providing a way of identifying alternative meanings. The rating system is summarised in Table 1.

Table 1: Details of the DER and U rating system

Rating	Degree (D)	Extent (E)	Relevancy (R)	Urgency (U)
X	Not applicable			
U	Unable to inspect			
R				Record only
0	None			Monitor only
1	Minor	Local	Minimum	Routine
2	Fair	More than local	Moderate	< 10 yrs
3	Poor	Less than general	Major	< 5 yrs
4	Severe	General	Critical	A.S.A.P.

It is possible to use one overall condition rating by combining the above three ratings but it is more difficult to be consistent. By considering each of the above ratings separately the inspector is able to concentrate on each aspect without confusing one for the other, and consequently obtain a more accurate rating of defects. It also simplifies the rating procedure and provides a more precise picture of the actual condition of the bridge to the bridge owner. With this method one can also produce more accurate budget predictions and maintenance, repair and rehabilitation actions to be used for preliminary work schedules used to carry out the work. In essence the bridge owner has a clearer and more accurate picture of the condition of the bridges in the network.

4 IMPLEMENTATION OF BMS

4.1 General

The phases involved in the implementation of a BMS are the following:

- Purchase a BMS software package;
- Customize the software package for the Client's unique needs;
- Populate the BMS with inventory data;
- Populate the BMS with inspection data;
- Analyse the inspection data and prepare various reports, such as structure priority lists, condition assessments, budget requirements, projects, etc.; and
- Maintain the system by adding new structures, new inspection data, maintenance activities, etc.

When purchasing a BMS it is important to keep the customizing of the software package to a minimum. It should ideally only involve updating basic information such as the client's name, logo, maintenance districts, maintenance depots, etc. It will also include integrating the BMS with the Client's other management systems.

The amount and quality of information available from the Client on the bridges and culverts would have an impact on the methodology to be followed in the implementation of the BMS and therefore also on the cost of the implementation. Specific issues to consider are as follows:

- Are the numbers of bridges, culverts, retaining walls and sign gantries known?
- Are there any inventory data available and, if available, in what format?
- Are there any data available from previous inspections and, if available, in what format?

The procurement of a BMS and populating it with inventory and inspection data would in most cases involve a tender process. For a tender process accurate information is required, such as the number of structures. If such information is not available, consideration should be given to first carrying out a scoping study and pilot study. The purpose of a scoping study would be to establish as accurately as possible the number and position of all structures under the jurisdiction of the client. This can be achieved by studying drawings and other records that the Client may have or using aerial photography if available, but in many cases it may require driving along all the streets and roads in the municipal area, stopping at every bridge or culvert, taking a number of standard digital photographs of the structure and recording the position of the structure using a GPS device.

Carrying out principal inspections on all the structures is the most costly part of the BMS implementation process. It is however very important that the inspections are done properly, as all future analyses, recommendations and decisions would be based on the information gathered during these principal inspections. It is therefore recommended that principal inspections are done by professional engineers or professional technologists with the necessary experience in bridge design and maintenance and with training in the application of the BMS's rating system. The estimated average cost for a principal inspection (including the capture of inventory data) is R4 000.00 per structure. The average cost largely depends on the distribution of span lengths of the structure population. To inspect 500 structures, for example, could thus cost approximately R2 million.

The analysis of the inspection data and the preparation of the required reports, such as structure priority lists, condition assessments, budget requirements, projects, etc, can be done in-house by the Client or could be outsourced. This decision will depend on the Client's available staff and their level of expertise. With any asset management system, continuity is very important and this must be kept in mind when deciding whether to use own staff or to outsource. The option that would best ensure continuity of the systems should be the one chosen. This is also applicable to the maintenance of the system by adding new structures, new inspection data, maintenance activities, etc. This would require a good working relationship between the Bridge Manager and the maintenance staff carrying out maintenance on structures. Flow of accurate information between the various parties involved is very important to ensure that the system is kept up to date.

4.2 City of Cape Town

The former Cape Town Municipality (CTM) was one of the first two clients in South Africa (together with Spoornet) to implement the CSIR bridge management system subsequent to the development of the Windows version of the BMS in 1994 for the Taiwan Freeway Bureau with Stewart Scott International. During the period 1996 to 1999, 142 bridges were inspected by CTM staff and 127 bridges were inspected by CTM using consultants. At this time (prior to the establishment of the UniCity in December 2000), the City of Cape Town covered 281 km^2 and contained 2 816 km of roads. After the formation of the UniCity, the area under the responsibility of the City of Cape Town (CoCT) increased to 2 468 km^2 and the road network increased to 10 234 km. The numbers of inspected and un-inspected structures in the CTM and the CoCT are summarised in Table 2.

Table 2: Summary of inspection status of structures in the City of Cape Town

	Former Cape Town Municipality (CTM)	**Current City of Cape Town (CoCT)** **(which includes former CTM)**
Known structures* (all authorities)	397	784
"Unknown" (unprocessed) structures (all authorities)	307	1 470
Known Council structures that have been inspected	269	569
Known Council structures that have not been inspected**	70	35
Known Council structures that have been re-inspected	2	218

* bridges, footbridges, culverts and subways

** many are Road-over-Rail or Rail-over-Road where CoCT has an agreement with Metrorail/Spoornet

As can be seen from Table 2, there are still a large number (1 470) of structures within the UniCity boundary that still have to be "processed" (i.e. to capture basic inventory data such as structure number, structure name and structure type) and the CoCT structures within this group must still undergo visual inspection. The current policy is that all structures should undergo a Principal Inspection every 5 years, but due to budget constraints this is currently not being achieved. The locations of the various structure types in the City of Cape Town are shown in Figure 1. This is an output of the CoCT's GIS, which has been integrated with the BMS.

Since 1997, a number of bridge rehabilitation projects have been carried out, a number of which were identified through the prioritisation procedure in the BMS Condition module. These are summarised in Table 3.

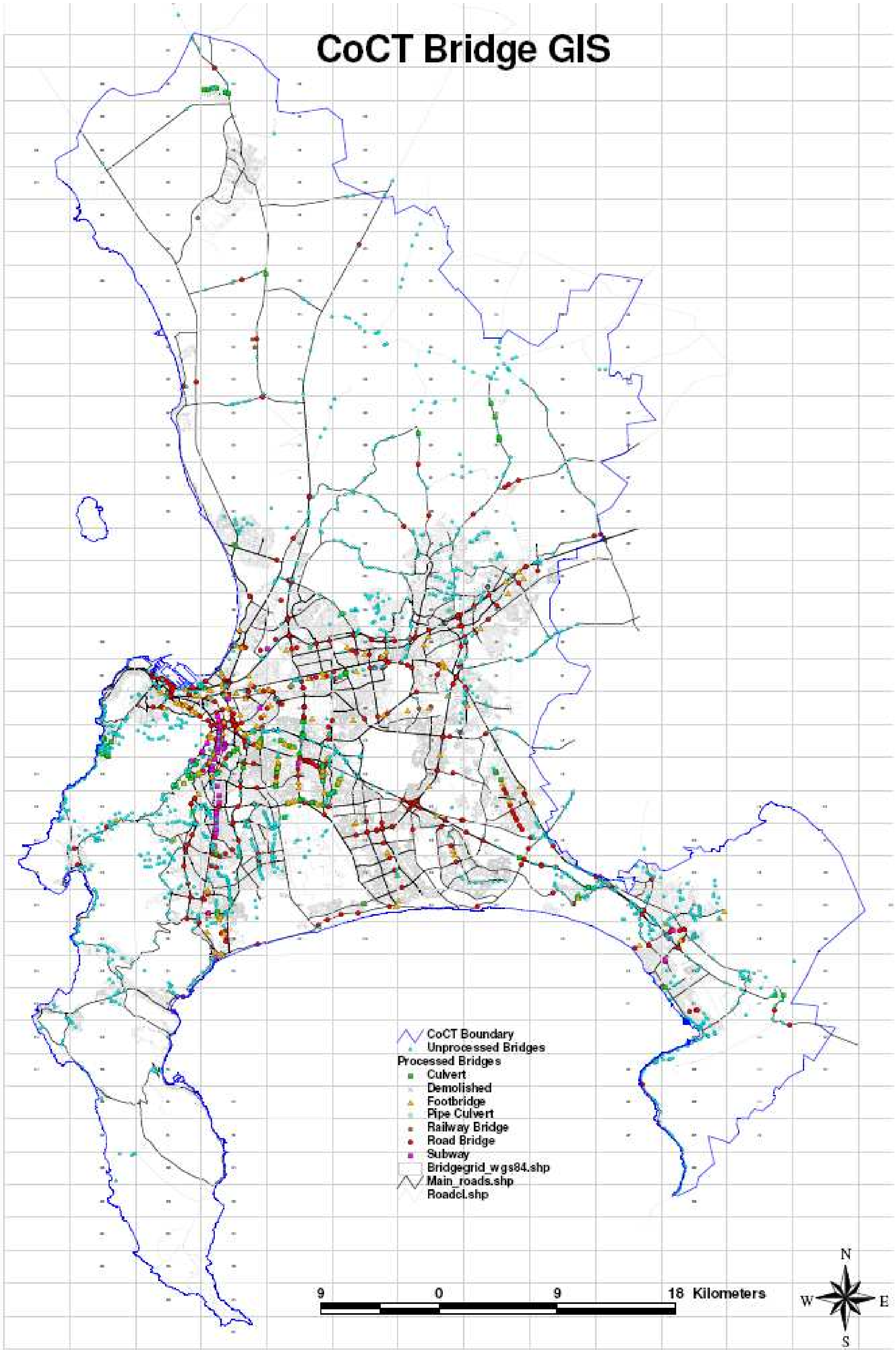

Figure 1: Location of various structure types in the City of Cape Town

Table 3: Structures repaired in the City of Cape Town, 1997 to 2006

Structure Name	Financial year	Type of repair
C18-19F - Liesbeek River Canal Footbridge (at Buchan Road), Newlands	1997/98	
B19-05C - Camps Bay Drive Lower (over Blinkwater Stream), Camps Bay	1998/99	
E18-32F - Nyanga Railway Line Footbridge (at NY4), Guguletu	1999/2000	
Foreshore Freeway Columns (Phase 1)	2000/01	Columns
Lansdown Road-over-Rail	2000/01	
Malta Road-over-Rail Handrails	2000/01	Handrails
Mitchells Plain Town Centre Bridge Steps	2000/01	Bridge steps
Footbridge over Liesbeek Canal at Roslyn Road	2000/01	
Manufacture of Temporary Handrail to replace stolen aluminium handrails	2000/01	Aluminium handrails
Vygekraal Footbridge Replacement	2000/01	Deck replacement
Weltevreden Road Bridge	2000/01	
Baden Powell Drive over Strandfontein Stream	2001/02	
Camp Ground Road-over-Rail Bridge hand railing	2001/02	Handrails
Embankment cladding - various	2001/02	Embankment cladding
Bridge Expansion Joints - various	2001/02	Bridge deck joints
Foreshore Freeway Columns (Phase 2)	2001/02	Columns
Foreshore Freeways	2001/02	
Joyce Newton-Thompson Bridge Embankments	2001/02	Embankments
Nelson Street Footbridge	2001/02	
D22-04F - Table Bay Railway Line Footbridge (at Donegal Street) - replace stolen aluminium hand railing with Council hand railing	2002/03	Replace stolen handrails
Royal Road Footbridge	2002/03	
Strand Street Footbridge Rehabilitation	2002/03	
D21-21F - Table Bay Boulevard Footbridge (at Paarden Eiland Road)	2002/03	
Eastern Boulevard Footbridges (Phase 1 - Design)	2003/04	
C17-03B&04B - M3 (over Trovato Road) - New expansion joints	2004/05	Bridge deck joints
D21-03B - Marine Drive (over Salt River Canal) - Rehab Abnormal Load Bridge (All Phases) [2003-2006]	2003/06	
Eastern Boulevard Fire Damage (Phase 1 - Design) [2005-2006]	2005/06	Fire damage
F31-02B - Old Malmesbury Road East over Diep River (Phase 1 - Design)	2005/06	
Metrorail (SARCC) Bridge Rehabilitation (Council to contribute financially)	2005-	

4.3 Nelson Mandela Metropolitan Municipality

The Nelson Mandela Metropolitan Municipality (NMMM), which came into effect in September 2000, is a combination of the erstwhile local authorities of Port Elizabeth, Uitenhage and Despatch and contains approximately 3 200 km of roads. The Port Elizabeth City Council was one of the first road authorities in South Africa to develop a bridge management system. The PE City Council originally implemented the DOS version of the CSIR BMS in 1989, originally developed by Scott & De Waal Consulting Engineers. This was the origin of the “defect-based” bridge management system in South Africa. Initially, 94 structures were inspected and captured into the system. In 2005 a decision was made to update the BMS to the latest Windows version and to expand it to include all municipal bridges in the municipal area of the NMMM. Afri-Coast Engineers were subsequently appointed in May 2005 to update the BMS and to conduct visual inspections on bridges in the NMMM. The total number of structures, excluding culverts, inspected during the project was limited to 116 which represent all the major bridges in NMMM. The remaining structures are mostly short span bridges and box culverts. Inspections started in June 2005 and were completed in May 2006. The NMMM has approximately 3 200 km of roads.

Bridges were named and referenced according to the grid reference system of the Mapstudio Street Guide, but can also be located using a GPS device. The majority of bridges are located within 10 km of the coastline and in close proximity of the Swartkops estuary, which is an aggressive environment. A large number of bridges (particularly on Settlers Way) are located within 5 km of the coastline. Other structures are scattered further inland around Port Elizabeth and Uitenhage. A bridge location map was prepared as part of the project. The map shows the positions of all structures in the BMS and highlights the top 20 bridges in the priority ranking.

The worst 20 bridges ranked by the Priority Index are presented in Table 4. Non-critical items (e.g. surfacing & sidewalks) were ignored in this analysis. This list is not the final list as further evaluation and verification inspections must still be done.

Table 4: Condition and Priority Indices for 20 worst bridges in NMMM ranked by Priority Index

Structure No	Structure Name	Inspection Date	Condition Index	Priority Index	PI Rank
QG-83_06B	Pell Street I/C (West To South Ramp)	2006/03/03	25.00	25.00	1
QK-84_01B	Lower Valley Bridge	2005/10/06	30.39	29.16	2
QF-83_01B	Darling Street Interchange	2005/08/02	49.27	44.58	3
QE-83_02B	Boswell Algoa Interchange	2005/07/27	69.87	57.94	4
QL-88_01B	Humewood Bridge (East Structure)	2005/08/30	63.63	64.41	5
QK-81_03B	6th Avenue Walmer Footbridge	2005/06/10	52.89	70.33	6
QE-83_01B	Boswell Algoa Ramps	2005/07/27	75.53	71.59	7
QG-83_08B	Pell Street I/C (North To West Ramp)	2006/03/03	81.84	72.10	8
QG-83_07B	Pell Street I/C (South To West Ramp)	2006/03/03	87.10	72.37	9
QG-83_04B	Pell Street I/C (Southbound) Causeway	2006/02/28	81.73	72.57	10
QG-83_02B	Broad Street Level Crossing	2005/09/06	75.28	72.80	11
QE-82_04B	Grahamstown Rd Over Rail At Kuit Rd	2005/09/06	63.41	74.19	12
PU-68_01B	Old Pe - Uitenhage Road	2006/05/18	73.45	75.01	13
QJ-82_01B	Albany Road Footbridge	2005/06/10	55.52	77.47	14
QH-83_02B	Albany Rd I/C (North To West Ramp)	2006/02/22	83.93	77.71	15
PK-87_01B	Coega River Bridge	2005/06/17	58.52	78.08	16
QG-83_05B	Pell Street I/C (West To North Ramp)	2006/02/28	86.81	78.26	17
QH-83_01B	Albany Road I/C (West To North Ramp)	2006/02/22	87.88	78.27	18
QB-84_02B	Deal Party Pedestrian Over Rail (North)	2005/07/28	75.74	78.28	19
QH-83_04B	Albany Rd I/C (South To West Ramp)	2006/02/22	89.47	78.44	20

Two bridges, Lower Valley Bridge and Darling Street Bridge, were classified as critical. Bridges classified as critical pose a danger to bridge users and can be divided into those that are in a structurally critical condition (danger of collapse) and those that are in a non-structural critical condition (no danger of collapse but danger to users). The two bridges classified as critical were both critical in a structural sense.

During the course of the visual inspection six bridges that require further investigation were identified. These are:

1. PW-81_02B - Dibanisa Road over rail, Swartkops
2. QB-83_01B - Baxter Street bridge
3. QL-89_01B - Hobie Pier
4. QJ-82_01B - Albany Road footbridge
5. QJ-85_01B - Baakens River bridge (West)
6. QJ-85_02B - Baakens River bridge (East)

Common problems relating to road user safety that were identified are the following:

1. Missing parapets
2. Low or poorly designed kerbs which could lead to vehicles falling off elevated bridges.
3. The risk of loose concrete (from corrosion of reinforcement) falling on vehicles and pedestrians.

The most common problem affecting bridge durability is corrosion of reinforcement. This problem occurs mostly to structures located within 5km of the coastline.

The estimated base repair cost of all defects based on the 2005/6 visual inspections is R74.8 million. In order to determine an estimated total budget, this cost was factored to take into account the following:

- Increase in estimated remedial work quantities taking into account the difference in quantity estimated from a visual inspection and a project level inspection (100%)
- Increase in unit rates to make provision for access to defects requiring scaffolding and traffic accommodation and for maintenance projects dispersed throughout the municipal area with relatively small quantities (100%)

- Project consulting (project level inspections, design, bill of quantities, tender documents etc.) (3%)
- Site establishment (10%)
- Site supervision (10%)

Taking the first two factors into account gives a total estimated budget of R224.4 million. This can be considered as the base cost and must be increased to take into account project consulting, site establishment and site supervision, giving a final budget estimate of R276 million to repair all bridges in the NMMM.

The combined length of all the bridges in the NMMM is approximately 10.7 km and the combined area is approximately 157 000 m^2. At an average construction cost of R6 000/m^2, the cost to replace all bridges in the NMMM in 2006 rand value would be approximately R941 million. The estimated repair costs of R276 million therefore represents 29% of the replacement value of the bridges. The NMMM is currently busy with the rehabilitation of the Boswell and Darling Streets structures at a cost of R2,3 million.

4.4 Johannesburg Roads Agency

The Johannesburg Roads Agency Ltd (JRA) is a self-contained company, owned by the City of Johannesburg. It was established in January 2001, and is responsible of the planning design, maintenance, repair and development of road infrastructure in Johannesburg. The area of jurisdiction is from Orange Farm in the south to Midrand in the north, covering more than 9 000 km of roads.

Prior to 1994, the area now covered by the City of Johannesburg comprised 11 local authorities, namely Alexandra; Diepmeadow; Edenvale; Ennerdale; Johannesburg; Midrand; Modderfontein; Randburg; Roodepoort; Sandton; and Soweto. Of these 11 local authorities, only the Johannesburg City Council (JCC) had a computerised BMS, while the Sandton Town Council had a report listing all municipal bridges in the Sandton municipal area with the required maintenance and repair items per bridge. The JCC BMS was expanded in 1996 to include all bridges on metropolitan roads in the expanded municipal area. The BMS at that stage contained approximately 350 bridges. After the establishment of the JRA in 2001, the need was identified for a BMS covering all the municipal bridges and major culverts for which the JRA is responsible.

A request for proposal (RFP) for a BMS was issued towards the end of 2003 with a closing date for submission of proposals 10 December 2003. The RFP called for the supply of a BMS, integrating it with the JRA's other asset management systems, populating it with inventory data for all municipal bridges and carrying out principal inspections on all municipal bridges. The RFP further called for the analysis of the inspection data and the production of the various reports.

The project was awarded early in 2005 to Jeffares and Green Consulting Engineers with the CSIR as sub-consultants for the supply of the BMS. The first phase of the project involved the customizing of the BMS for the JRA and the transferring of the inventory data from the old JCC BMS to the new JRA BMS. The inspection data from the old JCC BMS could not be transferred to the new BMS, as the rating method of the two systems is not compatible.

Principal inspections of the bridges commenced in February 2005. The number of bridges inspected per financial year is determined by the available funds. During 2005, 360 bridges were inspected and during 2006 a further 248 were inspected. The total number of bridges inspected to date is 608. The analysis of the inspection data must still be done.

Examples of defects identified during the principal inspections are shown in Figure 2 to Figure 5.

The BMS is managed at the JRA's head office and the various maintenance depots will have access to the BMS data via Citrix. ArcView is used to map the structures and links with the BMS database file.

Figure 2: Spalling on side of deck due to inadequate cover over reinforcing

Figure 3: Spalling on piers

Figure 4: Failed elastomer element in expansion joint

Figure 5: Accumulation of debris against piers

5 CONCLUSIONS

The successful implementation of a BMS at municipal level allows municipalities to have an up to date inventory of all structures for which they are responsible and to know the condition of these structures. It also provides information on where and what maintenance and repairs are required in priority order and gives an indication of the budgetary requirements for the maintenance and repairs. It ensures that, as far as possible, the available funds are spent in such a way so as to optimise the impact in terms of the improvement of the condition of the structures and the safety of users of the structures.

Furthermore, the implementation of a BMS as part of the implementation of infrastructure asset management at a local level assist municipalities to comply with the general requirements in the Municipal Finance Management Act that all assets of municipalities are to be managed economically, effectively and efficiently. It also enables municipalities as owners of structures to comply with the legal requirements relating to the inspection and maintenance of structures contained in the Construction Regulations, 2003.

6 REFERENCES

1. Government Immovable asset Management Bill. Minister of Public Works. (B1-2006)

2. International Infrastructure Management Manual (Version 3.0, 2006). South Africa Edition published by the Institution of Municipal Engineering of Southern Africa, 2006.
3. NORDENGEN, P A & NELL, A J. The development and implementation of a Bridge Management System for the Western Cape Provincial Government, South Africa. Proc. 5th International Conference on Bridge Management, University of Surrey, Guildford, United Kingdom, April 2005.
4. NORDENGEN, P A, WELTHAGEN D, & DE FLEURIOT E A bridge management system for the South African National Roads Agency. Proc. 4th International Conference on Bridge Management, University of Surrey, Guildford, United Kingdom, April 2000.
5. WALL, K. October 2005. Managing Municipal Infrastructure Assets. Civil Engineering, Volume 13, Number 10, pp 3-6.

7 ACKNOWLEDGEMENTS

The authors would like to acknowledge the assistance received from the following authorities with the preparation of this paper:

- City of Cape Town (in particular Mr Steve Roux)
- Johannesburg Roads Agency (in particular Mr Klaus Schaffrath)
- Nelson Mandela Metropolitan Municipality (in particular Mr Drikus Bester)