Bridge Asset Valuation and the Role of the Bridge Management System

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ABSTRACT:

Today, most if not all transportation agencies or Departments of Transportation (DOT) are moving towards implementing asset management systems or components of asset management systems.

Asset management systems for bridges generally answer fundamental questions about ownership, location, and condition, and most also address the cost of preservation and improvement needs, as well as the forecasting of future performance. But so far there are few tools to estimate the economic value of bridge assets and the effect of agency policy on this valuation. This question has become especially important to many agencies in response to GASB 34, and it is also a useful performance measure for management decision support.

Often without the ability to answer the question of “what is the value of our assets?” engineers and/or administrators are unable to adequately support an argument for increased funding of infrastructure (particularly when borrowing to finance improvements). In essence, the civil engineering community is facing a new era where valuation of infrastructure assets is being required, but the procedural guidelines/models needed are yet to be developed or adequately defined.

Fortunately, most modern BMS such as the Stantec Ontario Bridge Management System (OBMS), developed for the Ontario Ministry of Transportation, have all the necessary data and models to perform the asset valuation calculations for individual bridges, subsets of bridges, or for the entire network. In the particular case of OBMS, a new performance measure called the Bridge Condition Index (BCI), which is calculated based on bridge condition and financial weight or importance of contributing elements of the bridge, can be directly tied to the current asset value of the structure.

In this paper, methods to determine the asset valuation of structural assets are discussed, and means to carry out these calculations are shown which can be implemented in a bridge management system. Different GASB 34 compliant methods are shown which can be used depending on the agency preference.

INTRODUCTION

A major influence in the move towards asset management of transportation assets in North America has been the requirement for accounting of tangible capital assets within annual government financial statements, a requirement promulgated in the United States by the Government Accounting Standards Board’s (GASB) Statement 34, and in Canada by the Public Sector Accounting and Auditing Board (PSAAB). Agencies must determine the value of their infrastructure assets and demonstrate, through annual reporting, that the value of the asset is being maintained (GASB 1999, CICA 1998).

Also, there is an increased need for better and more proactive management of the transportation infrastructure to safeguard the investment of taxpayers. With infrastructure increasingly becoming a more high profile area of focus, taxpayers are becoming more knowledgeable and demanding in their expectations. Agencies are becoming aware of the need for fast, accurate, and defendable information concerning transportation assets.

Good asset management practice requires that the transportation agency be able to answer questions such as: “What assets do we have; where are they located; and what condition are they in?" In the case of bridges, most current Bridge Management Systems (BMS) address these questions (Pontis (AASHTO 2001), OBMS (MTO 2000, 2002)). Regulations are in place in most countries requiring DOTs to conduct annual or biennial bridge inspections to record the condition of all bridges on the highway system. This information and the inventory information necessary to populate the BMS is collected by most agencies on a regular basis.

However, not every bridge management system can answer the additional questions: " How many dollars do we need to maintain or improve the current condition?" and "What will the condition be as a result of a given level of funding?" This requires sophisticated set of cost, deterioration, treatment performance, and financial models specifically developed for the bridges in the particular inventory. Again, some BMS provide solutions to this problem (Pontis, OBMS for example).

In order to report the information that Statement 34 and PSAAB require, bridge agencies have other fundamental questions to answer – "What is the value of our bridge assets?", "What is the depreciated value of these assets? Although it would seem natural that BMS should be able to provide this information, BMS today typically fall short of the mark in the area of asset valuation of bridges. Agencies are therefore having to prepare bridge asset valuations manually.

This problem is compounded by the fact that traditionally, clear direction has not been given in the use of valuation methods for civil engineering infrastructure as a whole, and especially for bridges. Fortunately, considerable groundwork has been carried out over the last few years. With respect to the valuation of transportation infrastructure, the consensus is that there are two distinct accounting bases for asset valuation and either one is suitable.

In the Financial Accounting basis, historical costs are reported and current or book value is established by depreciating or amortizing the historical cost and reported annually. In Management Accounting, the current value is usually established as a written down replacement cost which considers the current replacement cost 'depreciated' to reflect current condition and reported annually.

Two general approaches to the asset valuation of transportation assets are described in GASB Statement 34 and are generally accepted today (GASB 1999, FHWA 1999, Stantec & Waterloo University 2000, Cowe-Falls 2004). These are the 'Traditional Approach (Depreciation)' and the 'Modified Approach (Preservation)'.

These approaches and an alternate approach are discussed in the next section. Methods to determine the asset valuation of bridge assets are given, and means to carry out these calculations are shown which can be implemented in a bridge management system.

BRIDGE ASSET VALUATION

Ideally, to report the value of an agency's bridge assets all historical costs would be known and recorded in the books over the life of the asset. In GASB Statement 34, it is recognized that these costs are not generally available retroactively and 'Estimated Historical Costs' are allowed for infrastructure assets instead of actual historical costs. The Estimated Historical Cost of an asset can be determined by calculating the current replacement cost and deflating that cost to the year of acquisition of the asset.

Statement 34 then requires agencies to depreciate the historical cost of the asset over the useful life. Two approaches are recognized in GASB Statement 34. These are the 'Traditional Approach (Depreciation)' and the 'Modified Approach (Preservation)'.

Traditional Approach (Depreciation) and the Modified Approach (Preservation).

The Traditional Approach is an annual valuation of the asset which uses the deflated historical costs, and depreciates those costs using (typically) straight-line depreciation over the estimated life of the asset. The costs of any preservation activities are included in the capitalization and depreciated along with the historical cost.

The Modified Approach is applicable to assets that are long-lived relative to other types of capital assets and which can be preserved, through maintenance, repair and rehabilitation, for a significant period of time relative to original service life. Bridges are a good example of this type of asset. In the Modified Approach, it is recognized that transportation agencies are striving to continually renew assets in order to extend their useful lives. Preservation costs are included in the capitalization of the asset, but are not depreciated.

Sample calculations using these methods are given in the next section.

It is noteworthy to mention that Statement 34 stipulates that the Modified Approach can only be used if certain criteria are met:

1) the agency must establish and make public condition goals (performance measures) for the assets on which they are reporting,

2) the agency must estimate the spending levels necessary to achieve or maintain the target performance measures,

3) the amount required to achieve or maintain the condition goals must be compared to actual spending,

4) the agency must document that the assets are being maintained approximately at or above the stated condition goals, and

5) the agency must perform condition evaluations at least every 3 years

To achieve these five criteria the agency must have a management system in place that can summarize the current inventory, assess the condition of the inventory, calculate the maintenance and preservation needs associated with alternative target condition goals and the budgets necessary to achieve those goals. Governments must be able to demonstrate that they have these capabilities.

Several considerations come to mind regarding these conditions. First there is considerable variation in what is understood to be a 'management system'. Second, there is considerable variation on what is an acceptable performance measure. Third, there is considerable variation on what is an acceptable 'condition evaluation'.

Fortunately, if an agency has a sufficiently powerful bridge management system (for example meeting the guidelines of the AASHTO Guide to Bridge Management Systems, (AASHTO, 1992)), that uses an accepted performance measure (for example a Bridge Health Index), that is based on a recognized condition evaluation (such as that used in Pontis in the USA, and the OBMS in Canada), then the criteria above can be met and bridge valuation reported automatically at any interval using the bridge management system.

One problem that has not been overcome is that existing bridge management systems do not specifically focus on the valuation of bridge assets and do not presently carry out these calculations for the user. It is the contention of the writers that most BMS already record most of the necessary data to carry out the asset valuation. A BMS can be used to quickly and efficiently evaluate bridge valuations for individual bridges, bridge networks, or subsets of networks.

Traditional Approach (Depreciation) Using Estimated Historical Costs

If the historical costs of the assets are known, then those costs are used in the valuation calculations. If these costs are not known, then GASB 34 allows the calculation to be based on the estimated historical costs calculated as deflated replacement cost adjusted for depreciation. Depreciation is usually taken as straight-line annual depreciation to zero over the estimated service life, rather than more elaborate depreciation curves or deterioration models. A 25 yr estimated service life is recommended but most agencies recognize this is too short for bridge assets. Forty (40) years will be used in the examples in this paper.

The replacement unit cost is an all inclusive replacement construction cost and should include all direct and indirect costs such as planning and engineering, construction, traffic accommodation, etc. Maintenance and preservation costs should be included but are typically not. This is not critical as long as the capitalization is done consistently year to year. Common to all methods based on average replacement costs, the replacement cost for bridges is taken as an average cost, rather than the more realistic cost for each type of bridge. Although this shortcoming is not serious as long as the valuations are done consistently year to year, the replacement cost estimates can be made more realistic through the use of a bridge management system, as discussed below.

In the calculations summarized below, the year of evaluation is 2004 and the average age of the assets in the inventory is 18 years. Taking the acquisition year as 1986, the price index** is taken to be 0.604 and the resulting historical cost is calculated as the deflated replacement cost. Historical Cost (Deflated) which equals $1,208,000,000. If the assets are depreciated linearly over the assumed 40 year service life, then the accumulated depreciation is $543,600,000. In this approach the annual depreciation is always the estimated deflated historical cost divided by the estimated useful life in order that the total accumulated depreciation cannot exceed the deflated replacement cost of the asset. The resulting valuation of the bridge assets is the Depreciated Historical Cost, which equals $664,400,000.

Bridge Asset Value Using Estimated Historical Costs (Traditional approach)

Bridge assets 2004	1,000,000	sq. m
Average replacement cost	$2,000	$/sq.m
Estimate current RC	$2,000,000,000	$
Average age of assets	18	yrs
Acquisition year	1986	
Price Index 1986 relative to 2004 **	60.40%	%

Historical Cost (Deflated)	$1,208,000,000	$
Estimated Service Life	40	yrs
Remaining Life (2026-2004)	22	yrs
Depreciation per yr	$30,200,000	$
Accumulated depreciation	$543,600,000	$
Bridges - Asset Value 2004 (Depreciated Historical Cost)	$664,400,000	$

** Price Index is taken from the ENR Construction Cost Index. Alternatively, the Federal Highway Administration's "Price Trend Information for Federal-Aid Highway Construction" is used (FHWA 1999a).

While this approach meets accepted standards, and is an excellent starting basis for agencies that lack other methods, one of the disadvantages is that the deflated and depreciated costs do not account for the real condition of the asset, which is a reflection of maintenance and preservation (or lack thereof). Further, the straight-line depreciation is simple to apply but does not reflect actual behaviour of the assets. There is a lack of confidence in the valuation of assets calculated using this method in that there is a high likelihood that the valuation either overestimates or underestimates the value of the assets. (Cowe-Falls 2004) This is potentially serious if it results in inadequate levels of funding for maintenance and preservation due to undervaluing of the bridge assets. Another challenge in using this method is that in order to calculate the depreciation, the agency must make an assumption on the remaining useful life of each of the assets, which requires even greater assumptions on the level of future maintenance and preservation activities.

Nevertheless the calculations illustrated above are easily performed by a bridge management system and reported or used by other systems. The results are useful as a reference or in comparison with other valuation methods as discussed below.

<u>Modified Approach (Preservation) Using Estimated Historical Costs</u>

In order to use the modified approach, the criteria listed above must be met regarding the use of a bridge management system, the establishment of condition performance goals etc. The estimated historical costs are taken to be equal to the current replacement costs. As with the traditional approach above, the replacement unit cost is an all inclusive replacement construction cost and should include all direct and indirect costs such as planning and engineering, construction, traffic accommodation, etc.

In the case of the modified approach, the costs are not depreciated but instead the preservation costs are reported as expenses in the statement of net assets. This is considered to be an appropriate measure of the cost of use of the asset because the preservation costs are reported as expenses.

Many of the same disadvantages of the Traditional Approach apply here also. The real condition of the asset is not considered and average replacement costs are used regardless of condition or type of structure. The main advantage is considered to be that the agency is not required to report valuations annually.

It is the contention of the authors that if the agency is using a bridge management system in accordance with the requirements of the modified approach, then the BMS can perform the calculations required to prepare a more accurate and meaningful valuation of the assets on an individual basis.

<u>Alternate Approach Using Estimated Historical Costs and Bridge Condition Index</u>

In management accounting, assets are often reported as a written down replacement cost (WDRC) which considers the current replacement cost of the asset written down or 'depreciated' to reflect current condition. For transportation assets, the WDRC method is a valuation method that is consistent with the Modified Approach (Preservation) in Statement 34.

The method has distinct advantages for bridge valuation compared to the other approaches: 1) the historical costs are not required, 2) the year of original construction is not required, 3) the current condition of the asset is considered in the valuation, and 4) the benefits of preservation carried out on a structure are recognized in the valuation. For these reasons, Caltrans utilizes this approach in the valuation of the bridge assets in the State highway system (Johnson 2003).

The written down replacement cost calculation can be done for each bridge asset in the inventory using a bridge management system and bridge condition index. The BMS will have stored the latest condition inspection and performance measure for the bridge assets, as well as the basic inventory data used to calculate replacement costs. The condition inspection should be based on an accepted inspection approach that considers all elements of the bridge and is accurate and repeatable from year to year and inspector to inspector. The Bridge Condition Index (BCI) can be a simple index that represents the bridge condition, but it is recommended that the index consider all elements of the bridge together with the relative economic weighting of the different elements as this is more meaningful in the valuation context (as well as performance measure context).

<u>Bridge Condition Index</u>

An example of a suitable condition index is the California Bridge Health Index (BHI) [Roberts and Shepard 2000, Shepard and Johnson 2004]. The California BHI uses element inspection data to estimate the remaining asset value of a bridge or a network of bridges. It does this by relating the remaining asset value of a bridge to current element condition states and element failure costs. Failure cost is defined as a combination of agency and societal costs associated with the replacement of the element, as well as user costs due to loss of service, risk to the public and general inconvenience. As a performance measure, the BHI is used to monitor network and individual bridge performance and to allocate resources throughout the network and to monitor the life-cycle performance of maintenance and rehabilitation actions.

> "*It operates on the premise that each element of a bridge has an initial asset value when the element is in new condition. Over time an element may deteriorate to a lower condition, resulting in a reduction in the asset value of the element. When maintenance or rehabilitation actions are performed, the condition of the element will likely improve, and the corresponding asset value of the element will be increase.*" [Roberts and Shepard, 2000].

In Canada, the Bridge Condition Index (BCI) was developed by the Ministry of Transportation of Ontario, for the Ontario Bridge Management System (OBMS). Developed by Stantec for MTO, the OBMS is a bridge management system intended for Provincial and State DOTs, small agencies and municipalities alike. The system has inventory and inspection modules, appraisals, roadway, project planning, strategic planning, and work accomplishment modules. The analysis is performed at the element, project, and network levels (OBMS 2000). The system uses an element-based, condition state inspection method that also has a unique system to record element level performance deficiencies (OSIM 2000, 2004).

In the OBMS, the BCI is calculated in much the same fashion as the BHI above with the main exception that instead of using failure costs for the element value, the BCI is based on the element replacement cost. This includes all of the costs of replacement of the element but does not try to include user costs due to loss of service, risk, etc.. The justification for using the total replacement cost of each element only is that the element 'failure' costs and user costs are notoriously difficult to quantify. Also, because MTO strives to keep all elements in good condition so that failure never occurs due to condition, MTO has philosophical concerns with using an element 'failure' cost.

There are four condition states (Excellent, Good, Fair, Poor). Poor condition is to be avoided in future planning but if it currently exists then the bridge must be moved to higher state as soon as possible. The asset value is determined by weighting the quantity of each element in each of the four condition states against the replacement cost of that element.

The BCI is calculated as follows:

$$BCI = (\sum CEV / \sum TRV)*100 \qquad (1)$$

where TRV is total element replacement value and CEV is current element value, calculated as follows:

TRV = Total element quantity * replacement cost of element RC

$$CEV = \sum (\text{Quantity Condition State}_i * WF_i) * RC$$

WFi is the condition state weighting factor for state 'i'

The Bridge Condition Index varies between 0 and 100, where 0 indicates that the bridge is in poor condition is and 100 indicates that the bridge is in excellent condition as defined in OSIM.

The BCI can be used to estimate the current bridge value (depreciated) as follows:

Current Bridge Value = Replacement Cost * BCI / 100

This is analogous to the written-down replacement cost but uses the BCI to reflect the current condition of the element. The BCI has the advantage that it accurately reflects current condition but also weights more important (costly) elements higher than those that are less important (costly).

Bridge Asset Value Using Estimated Historical Costs and Bridge Condition Index

Bridge assets 2004	1,000,000	sq. m
Average replacement cost	$2,000	$/sq.m
Estimate current RC	$2,000,000,000	$
Bridge Condition Index **	70.10%	%
Bridges - Asset Value 2004 (Written down replacement cost)	$1,402,000,000	$

** In this example this is an average BCI for the current year (2004) for all bridges

Although these are fictitious numbers, it is noteworthy that the bridge assets are valued at a higher valuation using the current condition than using the straight-line depreciated historical cost. If the bridges are maintained in adequate condition in accordance with a set performance measures (such as BCI greater than or equal to 70% or something similar), then the bridges will not normally depreciate to the extent that the straight-line depreciation model would suggest.

As can be seen, these calculations can be performed easily by the bridge management system using data that are typically stored in the BMS database. Furthermore the BMS can more accurately perform this calculation since each bridge can be calculated using a site specific replacement cost and BCI, removing the need to use system wide averages with the implied inaccuracies. This is particularly advantageous for many bridges such as a municipal or provincial network.

Bridge Replacement Costs

Bridge replacement costs in all the above mentioned methods are intended to include all construction costs necessary to replace the structure, such as planning and engineering, construction, construction supervision, traffic accommodation, etc. In addition to these costs, some agencies such as Florida DOT also include 'product support' costs such as materials and research costs.

For valuation what is important is the relative asset value year to year and therefore different agencies may account for different costs in the valuation. However, for budgeting purposes, bridge owners are best served if they account for all budgeted costs in the bridge valuation. One such cost that may be considered is the 'swell cost,' which accounts for a replacement structure of higher standard than what is being replaced, e.g. wider and/or longer.

Most agencies use average costs for the costs and factors mentioned above. Through the use of a bridge management system, it is easy to use specific costs and factors for each type of bridge or on a specific bridge-by-bridge basis to provide more accurate and realistic estimates. This is discussed further in the next section.

BRIDGE MANAGEMENT SYSTEMS AND BRIDGE VALUATION

It is recommended that bridge valuation capabilities be added to existing BMS and to any new systems under development. Most modern fully featured BMS such as Pontis, the Ontario Bridge Management System (OBMS), and several systems currently in development internationally have the necessary data and models to perform the asset valuation calculations for individual bridges, subsets of bridges, or for the entire network. Additionally, in the particular case of the OBMS, the Bridge Condition Index (BCI), which is calculated based on bridge condition and financial weight or importance of contributing elements of the bridge, can be directly tied to the current asset value of the structure. This explicitly satisfies the Modified Approach and in particular the Alternate Approach discussed above.

BMS can easily calculate and report several valuation methods. A variety of calculations can easily be performed and reported for specific tasks such as the valuation of all of a particular type of bridge, or all bridges on a particular highway, or in a district etc. As soon as the latest inspections are in the system, the BCI and bridge valuation calculations are automatically updated. The calculations are straightforward and most of the data already exists in the majority of bridge management systems.

In the OBMS, bridge asset valuation is part of a new module developed for the Province of Nova Scotia and released 2006. The module allows the user to view the valuation results for each bridge based on the GASB 34 straight-line depreciated valuation (Traditional Approach), and the written down replacement cost based on BCI (alternate approach based on Modified Approach). For each bridge, all parameters and valuations are stored, and bridge valuation reports are available.

For the network level, a list of all bridges with results from the two valuation methods is produced from the desktop or Table View. For the specified group or subset of bridges or for the entire inventory, the total asset value of the bridges is summed and shown.

Since the BCI is also one of the main performance measures in the OBMS, it is also used to set targets for condition, a requirement for using the Modified Approach. In the OBMS this is done at the network level in the network level budgeting screen (OBMS). The OBMS uses a 10 year budgeting horizon consisting of two 5 year periods.

Using the budget screen, the user selects the Bridge Condition Index as the performance measure. The user specifies a target value for BCI, and the system determines the required budget to achieve that target. For the required budget, a corresponding prioritized work program is provided. For a given work program, a report is available which lists the future BCI for the subset of bridges and the resulting bridge valuation. In this way, the BMS can provide all the necessary calculations and supporting information for the bridge manager.

SUMMARY AND CONCLUSIONS

A review of the asset valuation requirements for bridges has been provided. Several methods for calculating the asset value of bridges have been summarized including a preferred approach based on a written down replacement cost (WDRC) and bridge condition index (BCI). Examples were provided to illustrate the use of the different methods.

As the demands on agencies and those responsible for managing bridges increases, there should be higher expectations on requirements for bridge management systems (BMS). Bridge management systems can be a very useful tool in the asset valuation of bridges. Since the majority of data necessary to perform asset valuation calculations are contained in many BMS, then it only follows that the system should perform the valuation calculations as well. The argument is strengthened by the fact that the bridge condition index used in the condition inspection, and as a performance measure, can also be used in bridge valuation.

An example of how this has been carried out in Nova Scotia using the Ontario Bridge Management System was provided.

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