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Framework Development for Cost Comparison of DOT Contracting Methods

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Abstract: In the United States, Departments of Transportation (DOTs) generally use three types of road maintenance contracts: In-House contracts, Prescriptive-Based contracts generally called Method-Based Contracts (MBC), and Performance-Based Contracts (PBC). The In-House and MBC use prescribed methods to maintain road works. On the other hand, the PBC sets the performance standards of maintenance works to be complied by the contractor. The quality of work produced by these three types of contracts is not same. Therefore, the unit cost of the maintenance works performed using these types of contracts cannot be compared without considering the quality of work produced. Most of the literature reviewed during this study conducted a mere comparison of the cost of maintenance works performed using these types of contracts without considering the quality. This study proposes a new framework of comparison of these contracting methods by considering both cost and quality of the maintenance works. During this study, a comprehensive literature review related to the comparison of road maintenance contracting methods was conducted and summarized. A new cost comparison model based on life-cycle cost of maintenance works is proposed in this study. A detailed framework of the comparison model and the methodology to validate this model are described in detail. The cost and quality data currently is being collected. Therefore, the validation of this model is underway, and results will be reported in future conferences.

Keywords: Cost Comparison, In-House Method, Method-Based Contract, Performance-Based Contract

1. Introduction

In the United States, the Departments of Transportation (DOTs) have been using various road maintenance contracting methods to maintain their roads: In-House contract; Prescriptive-Based contract, generally called Method-Based Contract (MBC); and Performance-Based Contract (PBC). The use of these contracting methods depends upon the availability of staff in the DOTs, the degree of schedule complexity of the work, the requirements for specific knowledge or skills, the need to save money or time, the contractors' capability to perform the projects, life-cycle cost considerations, state statutes requirements, the types of maintenance activities, and the availability of guaranteed funding for a long period of time (NCHRP 2003, NCHRP 2009, Ribreau 2004).

With In-House work or also known as State Force, transportation agencies use their own staff and equipment, and purchase the required material to maintain their roads. Generally, In-House works are more flexible when scheduling a work and coordinating with staff because of the use of their own

resources. The expenses or payments depend on how long the laborers work and how much material is consumed for a project. Generally, materials are purchased prior to the start of the project, and laborers are paid on a monthly basis. The In-House contract is recommended for activities that need emergency response, e.g., snow and ice removal work (NCHRP 2009 and Ribreau 2003).

The MBC has been extensively used in maintenance projects as well as in new construction of roads, and is based on the 'Lowest Bid' method (Stankevich et al. 2009). In this contracting method, the contractor who bids the lowest dollar amount wins a contract, and then performs the given task according to the specification. The contractor is tied for "what to do," "when to do," and "how to do" (Stankevich et al. 2009). The payment to the contractor is made on the basis of the bid price and the measurement of quantity of work completed.

PBC was introduced in 1988 in British Columbia, Canada (Zietlow 2004). As suggested by its name, PBC focuses on the work performance of a contractor. In the PBC, the contractors do not have to follow the Prescriptive-Based specifications of the agency (Stankevich et al. 2009). The transportation agency transfers full risks of the contract to the contractor. Basically, this contracting method focuses on the output or performance of a work. The PBC uses the 'Best Value' method to select the contractor. In PBC, the contractor is paid on a monthly basis in compliance with the performance standards.

It is clear that the performance of these three types of contracting methods is not same. Specifically, their qualities of work produced are not same. Moreover, if cost data were collected from different states, they are not directly comparable because the task descriptions were not exactly same in all of these states. In addition, the difference in quality of work and specifications followed by these states made it harder to compare the cost of these three types of contracting methods (Halcrow 2011).

Many studies have concluded that PBC is cheaper than In-House and MBC method (Zietlow 2004, Zietsman 2004, NCHRP 2003, NCHRP 2009). The cost comparisons in these studies did not consider the quality of task. For a reasonable cost comparison, unit life cycle costs of maintenance works performed using these three types of contracting methods should be calculated. Therefore, in this study, a new cost comparison framework is developed for a more accurate comparison among In-House, MBC, and PBC costs.

2. Background

Through VMS Inc., the Joint Legislative Audit and Review Commission (JLARC 2001) reviewed 250 miles of interstate highway maintenance contract performed by Virginia DOT (VDOT). JLARC conducted interviews with VDOT personnel and contractor staff, visited site offices, analyzed contractor performance, and examined documents. JLARC concluded that the estimated cost savings, reported by VDOT as $ 23 million, was not supported by the detailed cost analysis documentation. Their cost saving was based on mere comparison of total contract cost with the estimate cost of that project. VDOT did not analyze the cost of performing this work by In-House contract or MBC.

Martin (1993) conducted a study determining true costs of In-House and out-sourced contract in order to conduct a reasonable cost comparison between those two methods. With In-House contract, direct costs were defined as fully dedicated costs for a target service; indirect costs were those that benefited more than one target service. Monitoring personnel could monitor more than one target services; therefore, the indirect cost associated with this should be proportionally allocated to all the target services in which these personnel were involved. The fully allocated cost for In-House contracts is the sum of direct costs and a proportional share of the indirect costs.

The author had described three types of costs the owners need to cover while performing out-sourced contract. They are 'contract administration cost,' 'one-time conversion cost', and 'new revenue'. A 'contract administration cost' referred to all the expenditures that occur from the time a decision took place to out-source the contract to the time when the contract is completed. The cost incurred when replacing an In-House contract by out-sourced contract is 'one-time conversion cost' that must be

amortized over an effective duration. The cost that the owner has to pay to the workers as their benefits and salary, because they cannot be removed immediately due to their contract clauses is the 'one-time conversion cost'. When the services were contracted out and an agency did not need to use some of the resources or equipment, the owner will sell out these resources or equipment. This accumulated money is termed 'new revenue'. The total cost incurred in an out-sourced contract is the sum of 'contract administration cost' and 'one-time conversion cost' minus 'new revenue.'

Pinero (2003) developed a conceptual framework to assess Cost Efficiency (CE) of Performance-Based Road Maintenance Contract (PBRMC). The author set two goals in assessing the cost effectiveness of PBRMC. The first goal was to assess the benefits of implementing PBRMC by merely determining the cost difference of maintenance work using PBRMC and using private contractor or In-House resources. The second goal was to assess the impact on Level of Service (LOS), if the same amount of cost that was expended in PBRMC, is expended on the maintenance work using the traditional method.

Anastasopoulos et al. (2010) presented a methodology to estimate the probability and amount of cost savings by using the PBC instead of In-House work. Road maintenance contract data were collected around the world. The authors also developed a model to compare these contracting methods to assist the transportation agencies in making the decision on whether to choose PBC or In-House contract for road maintenance work during the pre-planning phase. The cost saving can be calculated using Equation 1.

[1] $\%CS = \frac{(CB-CA)}{CB} * 100$

where:

%CS = percentage cost saving
CB = cost of the In-House
CA = cost of the PBC

Altogether, 337 contract data were collected from the various countries of the world between 1996 and 2007. The results showed that PBC had about 12% of cost saving in compared to In-House contract. In this analysis, the authors had just considered the life cycle cost of the maintenance works.

A tree diagram was developed based on the models results. The authors concluded that In-House method works better than PBC in the following scenarios:

- Low cost contracts
- Few activities work
- Bridge and tunnel contracts
- Shoulder maintenance work
- Emergency maintenance of facilities
- Short duration works
- Medium length of the road
- Landscape contracts
- Letter pick up

Similarly, the author suggested PBC for highly competitive contracts; long-extension contracts; huge projects, such as 400 lane-miles road contracts; illumination maintenance contracts; and those contracts consisting of many activities.

Halcrow (2011) conducted a cost and benefit study associated with out-sourcing road maintenance activities in Nevada state. The author collected data on maintenance cost information from Nevada DOT (NDOT), Utah DOT (UDOT), Texas DOT (TxDOT), and Florida DOT (FDOT) as well as from some private contractors. The total cost of an activity that is necessary to compare the costs among agencies and/or with contractors consist of the direct cost and indirect cost or overhead cost.

First of all, the calculation of direct cost was determined. The direct cost included all the costs directly associated with any activity or contract. To calculate the direct cost of In-House maintenance work, the total expenditure of the DOT's maintenance work – such as staff cost with fringe benefits, total material

cost, and total equipment charges – were taken from NDOT. The out-sourced contracts' direct cost is the contractor's bid price to perform a specified maintenance work. Moreover, cost associated with the state furnished materials, equipment, or a storage area, was also considered as the direct cost.

The indirect cost of the In-House and out-sourced maintenance work included the DOT, division, district, and maintenance station management costs. The actual cost of the staff was calculated as the percentage time allocation to the particular maintenance work. Other indirect costs included the costs of advertisement and quality control inspection works.

Halcrow stated that because of lack of data from NDOT to compare In-House maintenance cost with the private contractors cost, the cost data from other states also were collected and compared. The total costs of an activity were calculated by adding direct and indirect costs. The direct costs comprised of all the cost components that were directly associated with an activity, for example salary of staff and their fringe benefits, materials, equipment, advertisement for bids, building usage, specification writing. The indirect costs comprised of those costs that were not fully dedicated to an activity, for example the costs of state, division, district, sub district, and maintenance station management staff. The estimate of staff hour dedicated was determined by NDOT. Then, the author compared the unit rates of the 10 highest expenditure tasks of NDOT in 2009. Those tasks were chip seal, snow and ice removal, repair fill & cut slopes, paint stripe & solid lines, remove debris, pickup broom sweeping, crack filling, repair/replace traffic signs, and blade shoulders. The unit rates of these road maintenance activities were compared with the various cities of the Nevada and with some other agencies. For eight activities: chip seal, repair fill and cut slopes, remove debris, crack filling, blade shoulders, pickup broom sweeping, fog seal, and waterborne paint striping, the rates of TxDOT, FDOT, UDOT, and various cities in Nevada were compared as shown in Table 1. The table shows that the average rates of repair fill and cut slopes, blade shoulders, and waterborne paint striping are cheaper in comparison with FDOT, UDOT, and TxDOT. Moreover, the Ely city is comparatively cheaper for almost all of the road maintenance activities in Nevada.

Table 1: Comparison of rates of eight road maintenance activities of four DOTs and various cities of Nevada (Adopted from Halcrow 2011)

States and Cities of Nevada	Chip Seal (SY)	Repair Fill & Cut Slopes (CY)	Remove Debris (CY)	Crack Filling (LB)	Blade Shoulders (MILE)	Pickup Broom Sweeping (CY)	Fog Seal (SY)	Waterborne Paint Striping (MILE)
FDOT	-	35	-	-	4400	48	-	-
UDOT	-	-	-	-	-	-	-	485
NDOT	2.15	19	165	3.55	1650	125	0.40	380
TxDOT	2.10	-	110	2.95	-	90	0.30	795
Ely	2.15	23.5	125	3.05	650	90	0.38	290
Elko	2.15	26.5	195	3.45	1125	110	1.79	300
Las Vegas	2.3	30	155	6.20	1490	148	0.50	495
Tonopah	1.6	16.5	195	3.40	800	420	0.22	300
Reno	2.8	16.5	195	-	3200	105	0.50	420

However, the author only made the unit cost comparisons; there was no assessment of the performance or qualities of these maintenance activities. The author also did not explain whether or not the comparison included adjustments for time and location.

3. Objectives

The main objectives of this study are:

- To review the literatures related to cost comparisons of In-House work, MBC, and PBC.
- To develop a new framework for a reasonable cost comparison of maintenance works performed using these three types of contracting methods considering life cycle cost.

4. Framework Development for Cost Comparison

4.1 In-House, Method-Based Contracting, and Performance-Based Contracting Cost Components

The cost associated with road maintenance can be divided into work related cost and procurement cost. The work related cost could also be subdivided into direct cost and indirect cost. Direct cost is the cost that directly pertains to the progress of the work; labor, equipment, and material cost etc. On the other hand, indirect costs include division and district administration cost, site office cost, vehicle cost, cost for base-line survey, cost for inspection from DOT staff, cost of storage area, and cost of training programs. Procurement cost is the cost associated with procurement of the materials, equipment, and procurement cost of MBC or PBC.

The majority of transportation agencies in the United States maintain most of their road activities by their In-House work force. The agencies use their own labor, equipment, and material to maintain their roads. Figure 1 shows the cost components involved in the In-House work. A large part of this cost is the direct cost, which includes the labor, equipment, and material and staff involvement in a particular work activity. In addition to this, numerous indirect costs are involved, for example, site office cost, vehicle cost, and other indirectly involved staff cost. Another part of the cost that is not directly related to the work is procurement costs, which are spent during the procurement of labor, equipment, and materials.

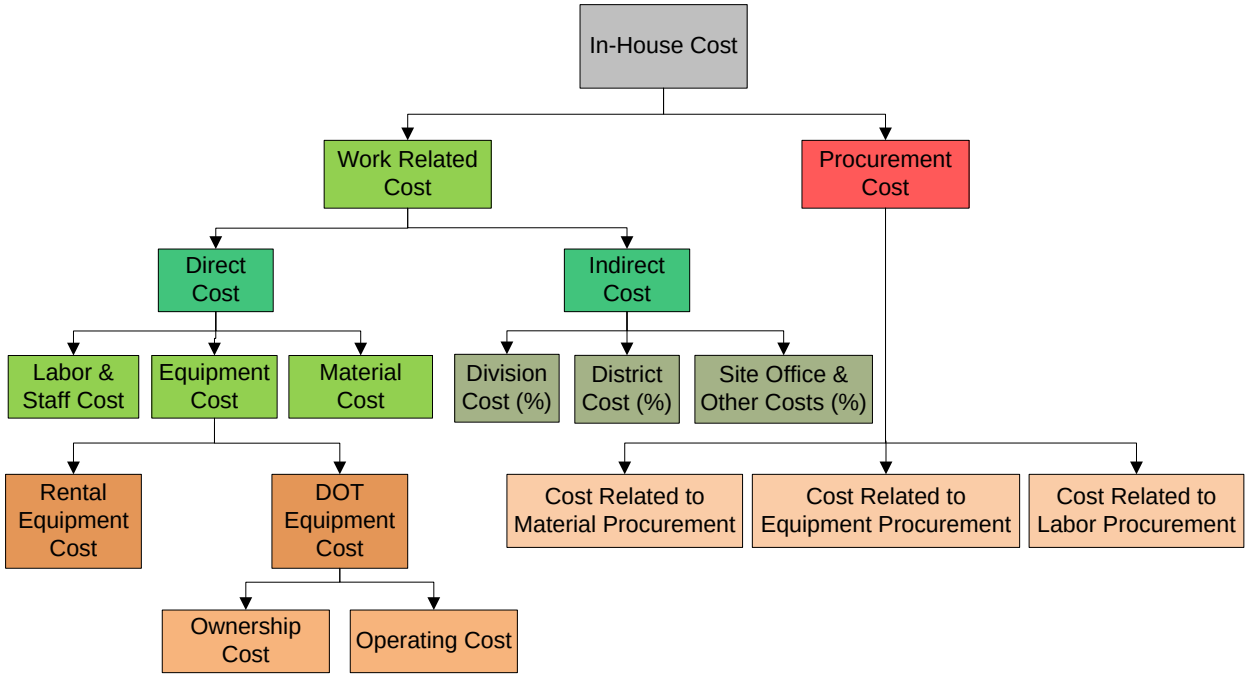

Figure 1: Cost Components for In-House Maintenance Work

For out-sourcing maintenance works, the MBC has been intensively used by transportation agencies, and still is used by many DOTs. The MBC refers to the completion of a task based on Prescriptive-Based specification and payment based on the bid price and a measured quantity of work. In MBC, the contractor is selected based on 'Lowest Price' bid. Figure 2 shows a detail of the cost components involved in MBC. The largest cost component of MBC is the total contract cost, which will be known at the time of the contract opening or contract award. Along with the contract cost, other costs that occur before, during, and after the contract award are a percentage share of division and district costs, DOT work inspection costs and cost associated with contract procurement and execution.

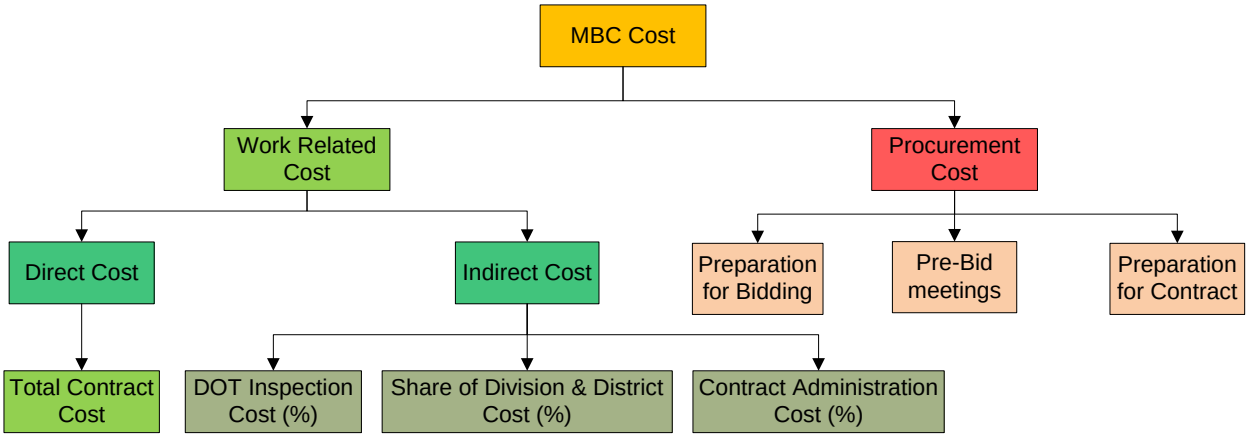

Figure 2: Cost Components for Method-Based Contracting

PBC sets performance standards — a minimum performance requirement of the assets to be complied by the contractor no matter how the task is achieved. Before the contractor starts maintaining the roads, a baseline survey needs to be conducted to assess the present condition of the road assets of a PBC contract. The cost of baseline survey is placed under direct cost if it is done only for a particular PBC contract. The performance measures of each asset are set so that the contractor's performance can be evaluated. To evaluate the output quality of the road maintenance and preservation projects, inspections or monitoring programs are prepared. There are various kinds of monitoring mechanism in PBC (Hartwig et al. 2005). The costs associated with all of these activities should be considered during cost analysis of PBC. A detail cost components of PBC are shown in the Figure 3.

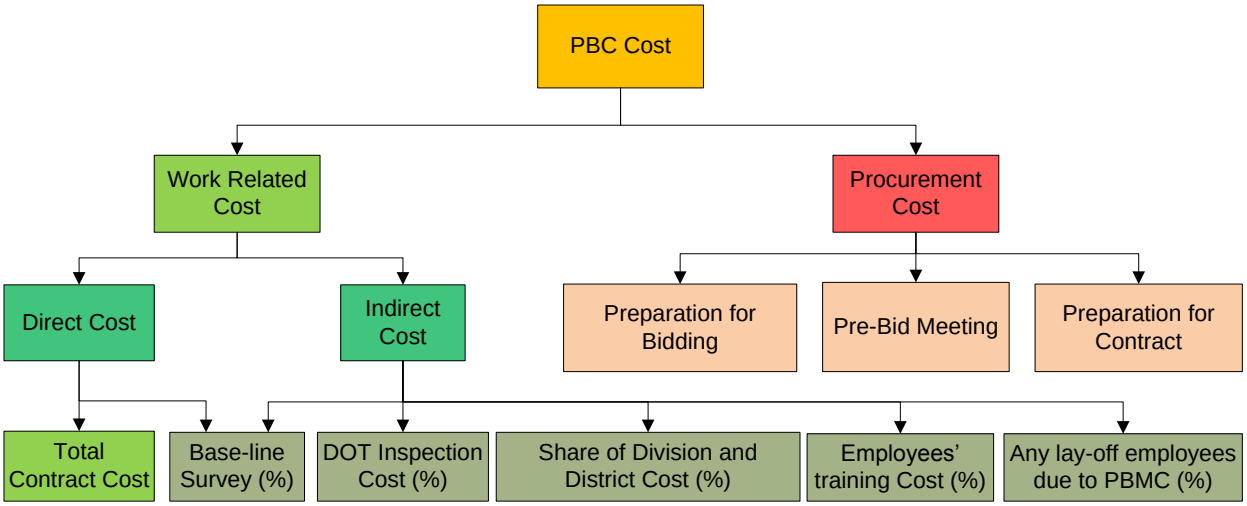

Figure 3: Cost Components of Performance-Based Contracting

4.2 Cost Comparison Framework Development

Several state DOTs use these three types of road maintenance contracting methods—In-House, MBC, and PBC. Specifically, in In-House work, DOTs complete road maintenance work by their staffs, and there is no warranty period for their work. In the MBC method, a contractor uses Prescriptive-Based specification; DOT staff conduct formal inspection—daily inspection, weekly, or monthly; and there is a short warranty period (generally 6 months) for the work completed. In this method, payment to the contractor is based on the bid price and the measurement of the quantity of work completed. In the PBC, a contractor completes work that complies with performance standards of the maintenance activities, and the work is inspected by either a DOT engineer or a qualified third party. As PBC is an output-based contract, it has a long-term warranty period and payment to the contractor is based on the contractor's performance.

Several studies conducted cost comparison and concluded that PBC is cheaper than both In-House contract and MBC (Zietlow 2004, Zietsman 2004, NCHRP 2003, NCHRP 2009). Halcrow (2011) compared the costs of 10 road maintenance activities of NDOT with costs of other states; the comparison took into consideration direct and indirect costs. Those comparisons did not consider the quality or durability of a work. For a reasonable cost comparison, the quality of work output or warranty period could be integrated by conducting a life cycle cost analysis. Various road maintenance-contracting methods have various warranty periods. For example, the In-House contract does not have any warranty period; MBC has a short-term warranty period; and PBC has a long-term warranty period of 2 years, 5 years, or even more. Therefore, to integrate those varying warranty periods, life-cycle cost analysis should be conducted for a reasonable cost comparison.

In this study, a new cost comparison framework was developed that considers quality of the maintenance work in order to compare the costs in a reasonable way as shown in Figure 4. Basically, the quality of a work is determined by the frequency of maintenance work, measuring the LOS, and also by customer satisfaction. Generally, a superior work lasts for a long duration and inferior work lasts for a short duration. In the framework developed by the study, the In-House cost is the sum of direct and indirect costs of a road asset, which can be determined by using Figure 1. The durability of In-House work can be determined by NDOT road maintenance records on how frequently a particular work activity such as chip seal is maintained in a particular route, for example, every two years, three years, or five years. The same methodology can be applied to the MBC work in order to determine the durability of the work performed by MBC contractor. In PBC, since it is output-based method and the contractor is responsible for maintaining the road over the contract period, the contract period can be taken as a measurement of durability of the work. The life cycle cost of an asset is the cost of all maintenance work performed over its life cycle.

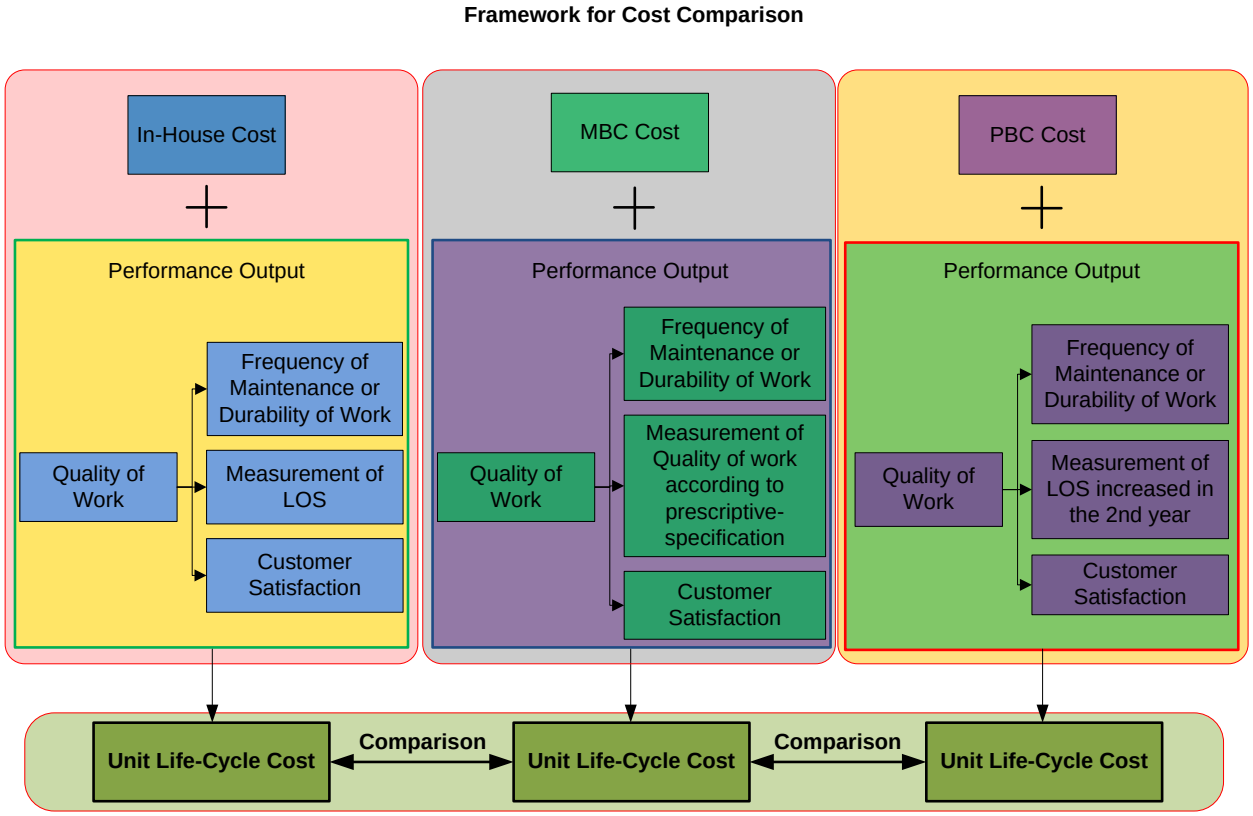

Figure 4: Cost Comparison Framework for In-House, Method-Based Contracting, and Performance-Based Contracting

A hypothetical data is considered here to describe the methodology of life-cycle cost comparison of these three types of contracting methods. The total cost of chip seal for In-House, MBC, and PBC is $10/SF, $7/SF, and $30/SF respectively. Similarly the durability of chip seal work is 3 years, 2 years, and 10 years for In-House, MBC, and PBC methods respectively. Considering the total life cycle of the pavement as 30 years, the total life cycle cost of these three contracting methods can be calculated as shown in Table 2. In this calculation the time value of the money is not considered. The analysis shows that the MBC method seems to be more cost effective based on initial installed cost. However, when the life-cycle cost of maintenance is considered, the PBC yields the lowest life-cycle cost.

Table 2: Calculation of Unit Life Cycle Costs of In-House, MBC, and PBC

Description	In-House	MBC	PBC
Total Cost of Chip Seal	$10/SF	$7/SF	$30/SF
Durability of Work	3 years	2 years	10 years
Life Cycle	30 years	30 years	30 years
Frequency of Chip Seal Work	10 times	15 times	3 times
Life Cycle Cost (without inflation)	$100	$105	$90

5. Data Collection and Validation

The cost data of all road maintenance activities performed under In-House, MBC and PBC methods in all the three districts currently are being collected from NDOT. The data collection consists of direct costs, indirect costs, procurement costs, any addition or reduction of staff, and durability of work produced by three methods.

After completing data collection, a validation of the proposed cost comparison framework will be carried out for four road maintenance activities—chip seal, striping, road sweeping, and culvert cleaning. These costs and work quality data will be plugged into the framework. This comparison should yield a reasonable cost comparison for the three contracting methods under study.

6. Conclusion

This study developed a new cost comparison framework to compare In-House, MBC, and PBC. This new framework was prepared to compare costs for three contracting methods based on life-cycle cost. To calculate the costs, the direct cost, indirect cost, procurement cost, and quality of the work currently are being collected from the Nevada DOT. When the data collection is completed, the validation of the framework will be conducted. Finally, unit life-cycle costs of work produced by all the three contracting methods will be calculated to conduct a fair cost comparison of road maintenance activities of NDOT.

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