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FRAMEWORK TO IMPLEMENT PERFORMANCE BASED CONTRACTS FOR ROAD MAINTENACNE

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Abstract
The traditional method of road maintenance contracts that includes a typical arrangement of Client, Contractor, and Consultant has been found ineffective and expensive in many countries. In the late 1990s, Performance Based Contracting (PBC) was introduced to address the shortcomings of the traditional methods of contracting. PBC has the potential for reducing the costs by 10-50 percent. A successful implementation of the PBC is a challenge for road authorities particularly in developing countries. This paper presents a framework to assist the road authorities to develop a culture needed to adopt implementation of the PBC

Introduction
The road authorities in many countries are confronted with the challenge of maintaining the road network at its highest level of service while investing the minimum amount of money. The traditional method of contracting is widely adopted that includes a typical tri-partite arrangement of Client, Contractor and Consultant as shown in Fig 1.

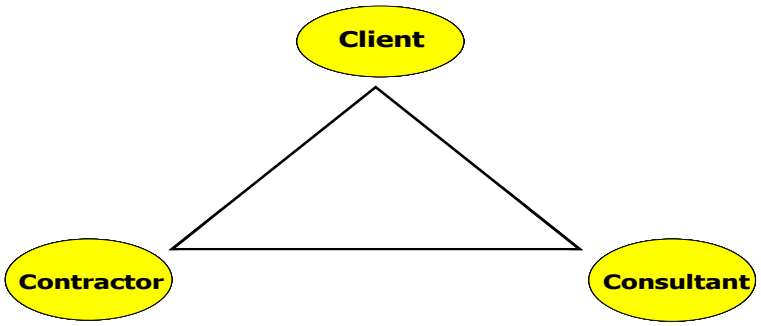

Fig 1 Traditional Tri-partite arrangement of Client, Contractor and Consultant

The traditional method of maintenance contracts has been widely recognized as ineffective and expensive as client (the road authority) has to supervise and pay to both Consultant and Contractor. Researchers for example [1-3] have highlighted the problems associated with traditional method, for instance, the common problems observed are escalation of cost and time, poor quality of work and inadequate motivation of contractors, no clear risk sharing between the owner and the contractor, and delay in project completion.
Over the last two decades the road authorities in many countries have experienced with the adaptation of the Performance Based Contracts (PBCs), which is also called outcome based procurement, in reference to competitive procurement processes that result in relationship where payments are made for measured outputs instead of the traditional way where the measurement and payment reflect the quantity of input [4-8].
In traditional method-based contracts, the owner agency specifies techniques, materials, methods, quantities, along with the time period for the contract. In contrast, in PBC, the client agency specifies minimum performance measures to be met or exceeded along the contract period. PBC is a type of contract in which payment is explicitly linked to the contractor successfully meeting or exceeding certain clearly defined minimum performance indicators [8].
One of the objectives of the PBC is to encourage contractor innovation and improve quality by applying value engineering and improved efficiency [2, 9]. PBC approach has been successfully used in several highway maintenance and rehabilitation projects in many countries around the world, for example, Canada, UK, Australia, New Zealand, Brazil, and Argentina.

Problem statement
It is not easy and straight forward to replace the traditional method of contracting with PBC. There are a number of challenges that could hinder the success of a PBC. For example, these challenges are selecting an appropriate contractor, existing legislation, technical capacity (skills and expertise) of the road authorities staff to define and monitor the performance standards, means or methodology to measure and report on performance standards, proper evaluation of the existing conditions of asset to establish

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Baseline and performance and payment security, warranties, and penalties. Moreover, the lack of pavement condition prediction models to understand and predict pavement condition. As the pavement deterioration follows a stochastic behavior, and the deterioration process and the improvement due to maintenance and rehabilitation activities varies based on many factors such as environment, loading, and data used for the modeling, which result in a higher risk to the contractor in PBC.
The risk of failure in PBC could be the result of contractor error in (i) predicting deterioration of contracted assets; (ii) determining appropriate design, specifications and materials; (iii) planning needed maintenance interventions; and (iv) estimating quantities. Therefore, there is a great need to develop a framework to facilitate the selection of an effective maintenance and rehabilitation program that takes into account possible measures to address the potential challenges.

Data collection

As a case study for this research the data was collected from the Emirate of Abu Dhabi. The Emirate of Abu Dhabi is one of the seven emirates or states of the United Arab Emirates (UAE). The Abu Dhabi Emirate is located in the western and southwestern part of the UAE along the southern cost of the Arabian Gulf. The total area of the Abu Dhabi Emirate is 59,402 square km which represents about 87% of the total area of the UAE [10].The Emirate of Abu Dhabi has over 35,000 km of roads with the highways composing of 10,363 km, and local and internal roads 25,000 km.
The various types of data were collected, for example, pavement condition data including roughness, rutting, surface macro texture, and pavement maintenance and rehabilitation strategies. These types of data were used to develop pavement deterioration models and optimization model. These models are important components of the framework proposed to implement the PBC.

Proposed framework for implementing PBC

In this section, a proposed framework is presented that could facilitate a successful implementation of the PBC. The various components of the framework were identified by performing an extensive literature review of the existing performance-based road maintenance contracts around the world and the existing approaches commonly used in the public and private sector for measuring and monitoring performance.
Fig 2 depicts the proposed framework. As shown in this figure two layers are considered in the proposed framework. The top layer illustrates the stages of the PBC while the bottom layer includes components that could be referred as supporting pillars required for an effective and successful implementation of the PBC.

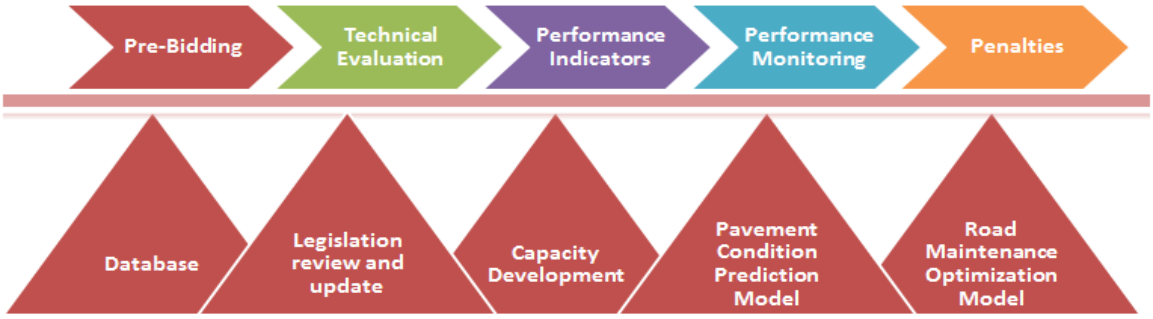

Fig 2 Proposed framework for implementing PBC

The details of each component of the proposed framework are discussed in the following sections.

Pre-bidding

Pre-bidding is an important stage to prepare the requirement of the projects including preparing contract documents. For the preparation of bidding documents, existing bidding documents used for road construction can be used, but they will have to be adapted to suit the special nature of PBC. The PBC that are being used in other countries might be helpful.
It is proposed to take a number of steps prior to the preparation of the bidding documents, for example, these steps are:

1. Clearly define the road network to be contracted out,
2. Make an inventory of the assets involved for contracting and assess their condition
3. Select and define appropriate performance standards
4. Select and define the methods of measuring defined performance standards
5. Define the likely maintenance and possibly rehabilitation works,
6. Prepare preliminary cost estimates.

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The data on the inventory and the conditions of the assets shall be given to the potential contractor as reference only. It is the responsibility of the contractor to make sure that the information is correct, since he has to assume responsibility for meeting the performance criteria.

At pre bidding stage the concept of PBC should be clearly understood by the road agency before considering the PBC particularly the objective of introducing PBC. The objectives for example, could be to lower the costs, to implement higher level government directives, to manage the road network with fewer staff, to improve user satisfaction. On the basis of the main objectives, the road agencies should choose the suitable PBC options.

Technical evaluation

After the pre-bidding, the project is set for competitive bidding to select the best bidder. It is wide recognized that under PBC, the value-based method is usually applied to select the bidder rather than the low-cost method. For example, in Finland, the selection criteria are weighted 75 % to price and 25 % to the technical aspect. In Washington, DC, the selection is based on the technical aspect and the price; the contract price has the biggest weight of 50 %, the technical aspect 20 %, staffing 5 %, management plan 5 %, quality control, 5 %, and past performances 15 % quality, but the lowest bidder was not always the winner. It is proposed to adopt the evaluation criteria and weights presented in Table 1.

Table 1 Proposed evaluation criteria to award PBC in Abu Dhabi

Criterion	Description	Weight
Technical	Experience, knowledge and understanding of issues relating to preservation and maintenance of the assets covered by this Invitation for Bids. Soundness of technical approach for meeting the performance measures for all of the assets.	20%
Staffing, Quality Control/Quality Assurance, Management	Staffing Plan	5%
	Management Plan	5%
	Quality Control/Quality Assurance Plan.	5%
Past Performance	The extent to which the Prime Contractor's and subcontractors' past performance on similar asset preservation, maintenance, and management con- tracts demonstrates a likelihood of successfully performing all of the tasks set forth in this Invitation for Bids.	15%
Cost	The extent to which proposed costs are realistic and reflect the likely overall cost to the government over the term of the contract.	50%

Performance indicators

Setting performance indicators is the most important characteristic of the PBC. The objective of setting performance indicators is to satisfy a set of goals such as to minimize the total systems cost, including the long-term cost of preserving road, and the cost to the road user, and to satisfy comfort and safety of road users. To avoid ambiguity, performance standards have to be clearly defined and objectively measurable. It is proposed to adopt the performance indicators presented in Table 2 for Abu Dhabi.

Table 2 Proposed Performance Indicators for PBC for Abu Dhabi

Performance Measures	Performance LOS
Potholes	Not more than 3 potholes with a diameter greater than 70mm on any 10km section
Roughness (asphalt)	IRI < 2.0
Roughness(bituminous)	IRI < 2.9
Rutting mm	< 10 mm
Cracks	Sealed

Performance monitoring

Monitoring the performance of the contractor regularly is a key to the success of PBC. It is important to establish a monitoring system to maintain the quality of work and also to record the data for future contracts. Appropriate control procedures as well as penalties for non-compliance have to be well defined in the contract documents. At present, road authorities in Abu Dhabi follow the criteria and standards developed for their traditional methods of contracting to evaluate the performance of contractor's

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inmaintaining road infrastructure systems. These standards have not been properly defined to monitor PBC. The development of revised performance evaluation procedures will ensure the reliability of the overall performance in PBC.
The researchers [1, 11-13] identified five components in order to develop a framework for monitoring performance in PBC. These five components can be applied as guidelines to establish a performance monitoring system for PBC in Abu Dhabi.
These components are:

1. Level of Service Effectiveness indicates the extent to which the performance criteria and performance targets defined in the contract are being met.
2. Timeliness of Response evaluates the response time of the contractor to service requests related to events or deficient elements in the roadway that need to be attended in a timely manner.
3. Safety Procedures evaluates if a safety program is properly implemented by the contractor. This component is very important to ensure that the roadway users as well as the maintenance crews performing the work are exposed to minimum risk of accidents.
4. Quality of Services assesses the customer perceptions with respect to the condition of the assets and contractor performance. Customers are the ultimate evaluators of the quality of the service provided; therefore, it is extremely important to assess their satisfaction.
5. Cost-Efficiency assesses the cost savings, if any, accrued by the government as a result of engaging a contractor to perform performance-based road maintenance services.

Penalties

Often, in traditional contracts penalties are not applied as specified to remedy the Contractors' failure to comply with the routine maintenance requirements. In PBC it is proposed to include a mechanism allowed for penalties to be applied when the desired quality or level of service was not achieved. It is proposed that penalties should apply for failure to meet the performance criteria. Table 3 presents a list of the proposed penalties that could be considered to apply for PBC in Abu Dhabi. As shown Table 6.3 for each item penalties for non-compliance are proposed in order to deter the Contractor from failing to comply. For example, a pothole left unrepaired beyond the specified time limit will currently cost the Contractor about AED 3,500 per day until it is patched. The total amount of penalties is deducted from the monthly payments

Table 3 Proposed penalties for failure to meet the performance criteria

Sections	Parameter	Requirement	Proposed Penalty (AED)
Subject to Rehabilitation	Pavement Roughness	IRImax. = 3 (AC) IRImax. =3.5 S.T/RC)	2000/week/km
	Pavement Rut Depth	1 cm max.	4,000/week/km
	Pavement Edge drop	0 cm	4,000/week/km
	Pothole dia.> 2.5cm	100% patched	4,000/week/km
	Cracking	100% sealed, and < 15% tipo 2 or 4	2000/week/km
	Concrete pavement joint cracks	100% sealed	2000/week/km
	Raveling	0%, and < 2% if surface treatment	2000/week/km
Subject to Routine Maintenance	Cracking	100% sealed up to tipo 4	2000/week/km
	Pothole	100% patched	4,000/week/km
	Raveling	100% patched	2000/week/km
	Paved Shoulders	Pothole/raveling=0 Edge drop=0; Rutting < 12mm Cracks sealed up	4,000/week/km
	Unpaved shoulders	No erosion, no rut, good transversal slope; edge drop <2 cm; width>=3m.	4,000/week/km
	Bush Clearing	Bush height < 15cm over 15m.	500/ha/week

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Database

Database component of the proposed framework is one of the supporting pillars for PBC.The database forms the backbone of road maintenance. A database including a thorough knowledge of the network, its performance and desired future service and performance levels need to exist or be developed. It is proposed to develop, regularly update and expand the database. Database shall be expanded to comprise the network referencing system around which is built an inventory of the network, and provides the framework within which all information about, or associated with the road network is stored and retrieved. It is proposed to ensure that the data collected provides information on the road inventory, pavement condition (riding quality, surface distress, and pavement strength), and traffic characteristics. The selection of data items to be collected must therefore satisfy the criteria such as relevance, appropriateness, reliability, and affordability.

Legislation

The legislation is another supporting pillar for successful implementation of the PBC. Successful performance contracting requires a robust legal, regulatory and institutional framework. The regulatory framework cannot be neglected, so the PBC should follow the legislative framework. Therefore, the selected PBC format needs to comply with the country's legal and regulatory framework. Some aspects of the contract format may be dictated by the prevailing environment. In this case the road authority may need to promote necessary changes to achieve the desirable format. For example, like many countries in Abu Dhabi the maximum maintenance contact duration is restricted to three years or less, making it necessary to change laws in order to accommodate long-term contracts.The length of the contract should be long enough for staff to retain technical skills to ensure consistent delivery but not too long to eliminate local competition.

For the long-term contracts, the authority requires performance security and the contractor needs payment security depending on the value of the contract. Performance security requires what if the performance quality is not met by the contractor. And the payment security requires what if the payment is not done on time or owner is unable to make payment. Under PBC, the bonds could be kept as a security with renewal options or the contracts could be made short term.

Capacity development

One of the critical and important supporting pillars for success of PBC is capacity development to build skills, expertise, and understanding of the staff at road authority, and contractors.Introduction of PBC can go relatively smoothly or be a disruptive experience for several reasons, in part, because staff and contractors must be prepared to make a significant cultural change. Capacity development training would have a major role to play in bringing about this shift and to help ensure that PBC works. Furthermore, as road authority accumulates experience with PBC and undertakes new contracting efforts, there is a need to communicate lessons learned.

The road authority has to acquire new skills and expertise to be effective in this new role of managing PBC. Some countries may decide to seek technical assistance from countries more experienced in the PBC approach, to build up their capacity. Others may find it more cost effective to engage consultants for assisting with this role, provided the domestic consulting industry possesses appropriate skills.Eventually it is needed to develop a PBC culture such as knowing the asset, managing risks and determining the sustainable level of service for the funds available.

Pavement condition prediction model

Another supporting pillar for PBC is the pavement condition prediction models. The main purpose of the pavement prediction models is to predict the future road conditions. It is proposed that road authorities shall develop robust and accurate pavement prediction models. These models can also assist in estimating the potential risk associated with the PBC for road authorities as well as for contractors.

Road maintenance optimization model

The last supporting pillar in the proposed framework is the road maintenance optimization model. It is proposed to develop an optimization model to streamline rehabilitation and maintenance activities and allocate budget for maintenance program. Like pavement prediction models, optimization model shall be developed by road authorities to assist and manage road maintenance strategies. More use of these models will help in improving the quality of these models as well as assist in developing an effective and efficient road maintenance mechanism.

Conclusions and Recommendations

A framework is proposed to help road authorities in adopting and implementing the PBC. The proposed framework will greatly assist the contractors as well as the road authorities to predict the pavement performance, and above all to optimize road maintenance strategies for effective utilization of resources to manage road maintenance contracts.

Given the proposed framework following are recommendations to facilitate adaptation of the PBC.

1. Gradually adopt the PBC by starting with a few pilot projects.
2. Develop and maintain a robust database of detailed knowledge of the road network that would be helpful in developing and updating statistical and optimization models.
3. Conduct regular training of the staff at road authorities necessary to develop capacity for managing PBC.

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4. Arrange commitment of higher level government and stable multi-year funding that would play a key role in successful implementation of PBC.
5. It is recommended for pilot projects extend the current limit of one to three years of maintenance contracts to at least five years.

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