A Strategic Plan for the Implementation and Monitoring of Performance-based Maintenance Contracting (PBMC) for Turkish Construction Sector

H. I. Ozturk[1], G. Atasoy[1], K. Ates[2]

[1]Department of Civil Engineering, Middle East Technical University, Ankara, Turkey
[2]Yüksel Proje Uluslararası A.Ş., Ankara, Turkey

Abstract

Roadway maintenance is significantly important to maintain the quality of roads, which can be achieved by successful contracting models. This study includes the identification of the implementation and monitoring strategies of Performance-based Maintenance Contracting (PBMC). Preliminary findings indicate that the advantages and challenges vary from country to country. In addition, cost efficiency of PBMC significantly depends on the length of the road network and the duration of the contact. Thus, each contract should be carefully evaluated during the feasibility study. Moreover, both the agency and the contractors should be trained before the implementation. Most importantly, for an effective PBMC implementation, crucial concern should be given to legislation, performance indicators and financial issues. Accordingly, in this study, a strategic plan is proposed for the implementation and monitoring of PBMC in the context of developing countries, especially for Turkey. It is going to be eventually inevitable to change the maintenance and rehabilitation strategies of Turkey in order to maintain the quality of the road network within low budget. Hence, this strategic plan is expected to guide the Turkish road administrators as it presents the requirements, challenges and advantages of PBMC.

Keywords: *Performance-based Maintenance Contracts, Road Maintenance, Strategic Plan*

1 Introduction

Turkey is a developing country, with a continuous need to improve its road networks. Due to this need, the funds are mostly allocated in new road construction. According to 2023 Strategic Plan of Turkey, the network will be expanding dramatically. However, this growth will bring excessive maintenance cost in the upcoming years. Therefore, a well-planned maintenance and rehabilitation strategy is required to manage the budget and the quality of the existing roads. Especially, to optimize the budgeting strategies, contracting model is significantly important. In-house and Method Based Contracting (MBC) are currently in use in Turkish construction sector. These traditional contracts typically lead to poor quality in construction, unbalanced risk sharing, high overhead costs and delays in the projects (Sultana, 2012a). Therefore, PBMC, which is a relatively recent contracting approach, has been used over the last decades to decrease the drawbacks of existing road maintenance projects. According to Hyman (2009), PBMC presents incentives and/or disincentives to the contractor to acquire certain quality in the final product while not specifying the method, timing and location.

About thirty-five developing and developed countries have performed PBMC that sets some performance criteria in addition to time and budget targets (Fuller et al., 2017). PBMC brings many advantages such as assurance of the quality of the work in the long run, decrease in the budget, reasonable risk sharing, developed level of services, innovative approach and decrease in the level of corruption and in the amount of claims during construction stage (Gericke et al., 2014). Although some of the developed countries successfully implemented the transition from traditional to PBMC, some studies revealed numerous challenges and drawbacks. Due to the lack of knowledge on these issues, there is no comprehensive framework to enable a successful transition from traditional contracting to PBMC. Hence, the motivation of this study is to address this need.

2 Literature Review

Major contracting types for road maintenance works are in house, method (MBC/traditional/input) and performance (PBMC) based (EBRD, 2016). In-house describes that the maintenance of the road projects are executed by the road agency/institutions via their own equipment, machinery, labour, technical personnel and sources. MBC is used when the resources of road agencies are insufficient so the agency outsources the job under special terms by specifying the method, timing and location. Contractors are mostly chosen by road agencies with tender procedure with a few exceptions (e.g., force major) and the payments are made according to the unit rates based on the volume of the work items (EBRD, 2016). On the other hand, performance-based is also an outsourcing model while the project is executed considering the predetermined indicators for the road segment by road agencies but not limiting the construction methods (de la Garza and Arcella, 2013). In theory, all these three contracting models aim an acceptable maintenance level at low cost. However, major problems are encountered in MBC including low quality, inappropriate risk allocation, extension of project duration, corruption, lack of training for agency staff. Hence, road authorities have been in search of a new approach for road maintenance contracting (Sultana et al. 2013). In reality, when effectively implemented, PBMC will ensure higher maintenance quality within the same budget or meet the same quality allocating a lower budget than the other contracting models (EBRED, 2016). For this study, research studies that have been performed in the last twenty years regarding the application of PBMC for road projects have been studied in detail. This literature review revealed many controversial topics regarding PBMC of road projects as described in the following sections.

3 Methodology

Research papers were scanned and the ones that contain the search terms of performance-based + maintenance + contracting were extracted. A total of fifty-one resources including research papers, reports, manuals and books have been found relevant after the screening process, and they were reviewed and classified according to their subjects and publisher type. Forty of these studies specifically focus on PBMC. Beside the academic journals, international financier and agencies and institutions have also published reports on the use of PBMC for road projects. Categorization of articles is shown in Table 1 in terms of their subjects and publishers.

Table 1. Categorization of the publications

Type of Categorization	*Type of Publications	Number of Publications
By Subject:	PBMC for Road Projects	13
	PBMC for Road Maintenance Projects	27
	Type of Road Contracts	4
	Road Maintenance Contracts	6
	Case Study	11
By Publisher:	Articles by Academic Journals	25
	Reports by International Funding Agencies	8
	Reports by Road Agencies / Institute	15
	Thesis by Universities	3

*Some articles include multi-subjects

Following the literature review, prominent breakdown for road projects are created to guide the implementation of PBMC in Turkey. Broad categories of cost savings & financing, innovation, risk allocation, staffing, duration, contracting, and quality of services & user satisfaction are generated under topic of characteristics and advantages; and subjects of tendering, staffing, and political & financial issues are discussed under the topic challenges and drawbacks. Performance Indicators and Legislative Requirements are other specified topics that are analysed individually.

4 Findings and Discussions

4.1 Characteristics and Advantages of PBMC

According to literature review, following characteristics and advantages are determined when comparing predominantly used contacting models.

4.1.1 Cost Savings & Financing

The key feature of PBMC is that payments are made according to the outcome with specified performance indicators, but not the quantity of work, equipment, labour or services implemented. Estimated cost of road maintenance projects are presented as per lane km per year, thus, road agencies have to consider all combinations of network length and project duration for cost savings. When comparing MBC and PBMC, estimated cost of projects executed by PBMC is always higher because the project duration in PBMC is significantly longer as compared to MBC (Anastasopoulos et al., 2010b). However in the long run, annually maintenance cost ends up being lower in the case of PBMC. In other words, PBMC provides benefits to road agencies for cost reduction by one's nature. (Zietlow, 2004; Anastasopoulos et al., 2009). The cost saving rates of PBMC obtained from developed countries (such as Canada, England, Australia, and USA) are in the range of 10% to 40% (a mean of 25%) when compared to MBC (de la Garza and Arcella, 2013). This comparison is also done between the PBMC and in-house models on road projects and 15% to 38% cost savings are obtained in the states of Australia and New Zealand (Sultana, 2012a). In some countries, due to the absence of the data for road maintenance, cost saving comparison between the contracting models is not possible.

The experience of PBMC in different countries indicated that the percentage of cost savings in large networks with longer contacting durations is higher (Zietlow, 2005; Anastasopoulos et al., 2009; Sultana, 2012a). Capability and experience of contractors are important, considering the long project durations (between three to ten years in general) and taking into account the transfer of all responsibility to contractors (Ahmed et al, 2012). The main reason of the cost efficiency is indicated to come from the independence of contractors for applying innovative approaches such as use of advanced materials and equipment, improved design and new construction techniques without any contracting restrictions. This freedom leads contractors to arrange and improve the work and schedule and decrease the indirect cost while meeting the client's performance criteria. With these gains, the contractors have a chance to increase their profit in the long run (Anastasopoulos et al, 2010a). Especially, in the long-term, PBMC offers around 21% reduction in indirect cost with effective labour force, proper equipment and optimum material (Anastasopoulos et al, 2010b; Sultana, 2012a; Zietlow, 2005). In tendering process of PBMC projects, road agencies prefer best value selection combined with financial proposal and technical proficiency, instead of only considering the lowest bid. In addition, successfully implemented PBMC has an impact on social cost of countries by decreasing number of fatal/ severe accidents on road network during the contract duration (Manion and Tighe, 2007). While providing cost efficiency, PBMC enables an increase in the level of services and a decrease in the risk of owner under road maintenance works (Sultana, 2012a).

International financial institutions especially the World Bank supports and guides the road agencies to alter their contracting type to performance-based. Since the implementation of the first PBMC project in between the years of 2002 and 2003, the World Bank has funded over 200 projects (Sultana, 2012a). Thus, developing countries can develop their economies and construction sector by means of new contracting approaches with the assurance of international financiers (Zietlow, 2005; Sultana et al., 2013). PBMC for road projects should be supported with a stable funding system due to the long duration and high value contracts (Madelin and Parkman, 1999). Practically, in developing countries such as Turkey, continuity of project funding is a fundamental issue for the contractors to prefer PBMC.

4.1.2 Innovation

One of the fundamental properties of PBMC is that the contractor implements innovative approaches for the selection of materials and methodologies at the stages of design, construction, and operation. In other words, PBMC allows the contractor to choose all methods and materials freely under the circumstances of meeting the performance criteria (Molenaar and Yakowenko, 2007; Anastasopoulos et al., 2010b). Especially, usage of technology for innovative approaches depends on engineering and reproductive capability of contractors (Sultana et al, 2013). This innovation brings about reducing the cost of construction items in the long term. In some cases, initial investments may be higher when compared to other methods. However, it is revealed that the productivity, the motivation of the contractor to focus on developing a new technique, and flexibility for optimizing the technical solutions and work schedule without any restriction increase (Stankevich et al., 2005; Sultana et al., 2013). On the other hand, innovative approaches may cause problems due to the inherited unknowns. Hence, the contractors shall consider all risks and unforeseeable results (Anastasopoulos et al., 2010b). In order to decrease the chances and impact of such risks, contractors can invest in Research and Development which can result in secondary benefits for the construction industry.

4.1.3 Risk Allocation

By PBMC's nature, responsibilities and risks of the project are substantially transferred from the road agency to contractors when compared to in-house and MBC, because, additional freedom given to the contractors brings essential risks (Zietlow, 2005; Sultana et al., 2013; EBRD, 2016). From the point of road agency, the road maintenance projects will result in cost efficiency with less responsibility (Sultana et al., 2013). Such risk transfer increases the possibility of project terminations if the contractor is not experienced or well prepared with contingencies (Hardy, 2001). Hence, road agencies take the risk of under-performance or cost of retendering in the case of termination. From the contractors' perspective, transferral of such risks are compensated with cost reduction and increment of profit margin in the long term (Zietlow, 2004).

4.1.4 Staffing

PBMC enables road agencies to retain limited number of well-qualified in-house staff when compared to MBC (Zietlow, 2005; Sultana, 2012a; Wirahadikusumah et al., 2015). With minimum administrative labour, expenses of road agencies are decreased and the project is performed more efficiently (Sultana, 2012a). After excessive personnel reduction, road agencies should develop a new organizational structure and train their employees for this new contracting method. Training and restructuring are usually outsourced to the third parties with experience (Sultana et al., 2013).

4.1.5 Duration

Except the pilot projects (about three to five years), duration of PBMC takes much longer when compared to other contracting models and are usually in the range of five to seven years (EBRD, 2016). This long contract duration comes with benefits such as contractors can invest in construction equipment, especially for distant fields in the long term and reduce the risk of loss (Tamin et al., 2011). Meanwhile, staffs of contractors gain wide experience of that specific field of the road network during long contract term. Zietlow (2004) stated that staffs are able to understand the network and have enough time to implement initiatives based on this knowledge as well as understanding which areas of the network are under stress and how these areas are likely to react to extreme events. Moreover, long duration gives chance to contractor to improve management strategies and minimize the risk by using the first year of the project for understanding seasonal effects and taking precautions for the following years. This approach may lead to an increase in the initial cost, however; operational cost in the lifecycle of project would decrease gradually by proper actions. As opposed to the presented benefits, the risk of continuity of funding over years by client should be considered. Road agencies, municipalities or financiers shall arrange budget for the project and provide the funding during the full term of the contract (Zietlow, 2005).

4.1.6 Contracting

PBMC should contain explicit information regarding standards, monitoring procedures and indicators in addition to typical contract documents (e.g., specifications, drawings). Detailed financial aspects including incentives, disincentives, inflation and payments should also be planned and clarified according to the industry characteristics. Incentive is applied when contractor reaches higher standards than specified indicators and disincentive (penalties) is applied when contractors fails to fulfil the specified indicators. Inflation rate should be identified and updated for each consecutive year, after the first year. In addition, invoicing process (generally monthly), submission of reports, self-monitoring schedules shall be identified. Accordingly, the response mechanism for emergency works and force majeure shall be clarified in detail (Tamin et al., 2011).

Differences in the payment methods are observed according to implemented country. For instance, according to CREMA (Contrato de Recuperacion y Mantenimiento) experience in Argentina, the contracts are made on fixed-prices basis including the construction and maintenance stages. The overall contract duration is determined to be seven years, in which two years is allocated for rehabilitation and the rest is for the maintenance stage. The payments are initiated with an advance payment for site mobilization and continues with four equal lump-sum payments given semi-annually during the construction period. The maintenance payments are provided monthly thereafter. Payment of emergency works is made based on unit price with specified quantity, equipment, and material to be supplied or executed (Cabana et al., 1999). As observed in this example, PBMC does not have to be in a "pure" form. It can be "hybrid" as some services can be paid on a unit rate basis, while others are linked to meeting performance indicators (Stankevich et al., 2005).

4.1.7 Quality of Services & User Satisfaction

PBMC keeps the quality of the network at a steady level by providing sustainable road management and regular maintenance under operational life, meeting the agency requirements. Hence, comfort, safety and satisfaction of users will be ensured continuously (Zietlow, 2004; Tamin et al., 2011). Health and Human Services Department of USA presents principal components of PBC, and two of them related with the continuity of quality and serviceability are: (1) Acceptable Quality Level (AQL) providing the required variations for performance indicators and (2) Quality Assurance Surveillance Plan (QASP) providing assessment of contractor performance to meet the required indicators (Tamin et al., 2011).

The road users are indicated to be more satisfied with using high quality roads due to comfort, safety and reduced vehicle maintenance cost (Sultana, 2012a). One of the essential aims of PBMC is to provide road users high quality services meeting their need. The degree to which these needs are addressed is evaluated using performance indicators reflecting transportation values such as traffic safety (injuries and fatalities), mobility and speed (delay, congestion, average travel speed, closures and detours.), reliability of road network environmental protection, user benefits (travel time reduction, vehicle operating cost reductions), and comfort/convenience etc. (Haas et al., 2009). Moreover, additional advantage of lower complaint by users is reported for the cases of New Zealand and Estonia by maintaining higher maintenance quality (Sultana et al., 2013).

4.2 Challenges and Drawbacks of PBMC

The biggest challenge in developing countries is inexperience and insufficient know-how and lack of guidelines. The mostly emphasized challenges of PBMC are tendering, staffing and political and financial issues.

Tendering: The major challenge in this stage is the number of contractors willing to take place in the bidding due to high cost of the tender and bid value. Hence, the number of bidders may reduce and limit the chance of smaller firms to bid unless they establish consortiums (Sultana et al., 2010b). Additionally, inexperience and lack of competition between the contractors may arise and lead to an increase in bid value. Therefore, a proper planning and screening is required for the prequalification and bidding stages. (Tamin et al., 2011; Sultana et al., 2013). Indeed, the bid evaluation is challenging and complicated for the agency due to the variations in the designs, schedules and costs. Hence, the contractors should prepare their work schedule clearly to implement requirements (de la Garza et al., 2009).

Staffing: The staff of the road agencies are generally opposed to changing contacting model to PBMC because of the fear of losing their position in the agency as the reduction of in-house staff is the typical characteristic of PBMC. Besides, many people feel more secure to work in public sector than private sector in developing countries (Sultana et al., 2013). Moreover, at the layout stage the agency should be very cautious to keep the senior experienced staff to overcome possible problems in monitoring and oversight to protect the interests of the government (Madelin and Parkman, 1999; Sultana et al., 2010b).

Political & financial issues: For the transition to PBMC, support from political figures is required to start up the process so that the legislative changes can be performed. Governments need to re-establish their organizational structure, manage their staffing and provide the required funding (Madelin and Parkman, 1999). However, taking part in multi-year contracts might be a burden on the Ministry of Finance of developing countries. The top-level management should allocate continuous funding for the monthly operational payments (Sultana et al., 2013). Since the contractors need a guarantee for the payments, the interest rate should be taken into account for the full term of the project. The international standard practice dictates that the interest rate should be set to a rate that is higher than the borrowing rate of the contractor (Wirahadikusumah et al., 2015). In addition, cost estimation may be problematic in the pilot projects due to the lack of knowledge (Sultana et al., 2010b). According to the gained experiences, the cost efficiency increases proportionally with the length of road segments up to 600 lane-miles (Anastasopoulos et al., 2009). Contractors should allocate the 50% of total contract value for the first year and keep the rest for future maintenance activities (Wirahadikusumah et al., 2015).

According to the accumulated experience from various countries, such challenges and drawbacks can be resolved by proper planning and staffing of road agencies; involving capable and innovative construction companies; assuring balanced risk sharing; and also assuring financial requirements through national or international funding sources.

4.3 Performance Indicators

Strength of PBMC relies on the quality of performance indicators. Thus; determining the indicators with precision is one of the most critical steps of this contracting type (de la Garza et al., 2009). While specifying the indicators, challenges should be taken into account including deterioration caused by high speed overweight vehicles, evaluation of physical status of the road, setting monitorable indicators, existence of database for current road conditions, roadside facilities such as cables, irrigation canals (these structures or materials are out of PBMC scope), and adverse geographical conditions (Tamin et al., 2011; Haas et al. 2009; Wirahadikusumah et al., 2015). Principal performance indicators that have been used in PBMC in the past are summarized in Table 2. These items have already been studied and analysed for road maintenance in Turkey according to flexible pavement manual published by General Directorate of Highways and current conducted contracts for road maintenance projects tendered by MBC. Therefore, transferring from method-based to performance-based would be straightforward in terms of specifying the indicators criteria.

Table 2. Summary table for principal performance indicators used in PMBC at road projects

Principal Indicators		
-Pavement Roughness (IRI)	-Patching	-Guardrails / Road signs and markings
-Potholes	-Shoulders	-Snow Removal and Ice Control
-Cracks	-Drainage Systems	-Accident Response (Traffic Control
-Rutting	-Vegetation, Control and Cleanliness	and Clean-up)

4.4 Legislative Requirements

To successfully conduct PBMC on road projects and avoid conflicts of interest, legislative requirements are necessary regarding the government agencies and road users. Especially, extensive database usage is necessary for identifying and monitoring the performance indicators. If a database does not exist, it must be created legally to collect and store data for road projects. If it exists, access regulations for all stakeholders should be rearranged by legislative changes (Wirahadikusumah et al., 2015). Accordingly, if more than one agency or ministry, which are responsible for road maintenance based on governmental policy, have to cooperate in all stages, their interactions should be maintained by law (Tamin et al., 2011). Meanwhile, the financial arrangements for long duration contracts have to be legislated by consent of ministry of finance to allocate funds to the road agencies (Tamin et al., 2011). Notably in developing countries, PBMC could only have limited affect for the reduction of corruption and illegality. Willingness and attitudes of the government agencies and political issues are effective for these countries (Sultana et al., 2013). For instance, if the inspectors employed by the road agencies tend to be bribed, the consequences will be worse than MBC (Sultana et al., 2012b). Also legal precautions should be taken against road users. For instance, after completion of the initial maintenance phase, overloaded vehicles can cause heavy damage to the road and it must be repaired according to performance indicators in addition to routine maintenance (Wirahadikusumah et al., 2015). This leads to considerable increase in the maintenance cost (Tamin et al., 2011). Therefore, effective control systems and severe penalties have to be imposed to user of overloaded vehicles by legislative regulations. Local administration must take responsibility to prevent these issues.

5 Suggestions

According to the issues discussed above, the implementation and monitoring of PBMC should also be considered in Turkey. Building up on the know-how gained from the literature review, suggestions for the proper transition to PBMC have been identified. These suggestions, including the authors' self-comments and interpretations, are synthesized as a strategic plan and presented in Figure 1. Due to space limitations, only a set of suggestions is presented in this figure. The strategic plan involves four parts: discovery, engagement, development and implementation. Initially in the discovery part, information should be gathered related with current capabilities, regulations and financial status and experiences of other countries. Integrating this information with a SWOT analysis, strategies should be identified. Secondly, in the engagement part, governments should perform pilot studies, get different stakeholders involved, and plan for the selection of qualified contractors through a tendering process. Thirdly, the development stage, which is the most crucial one, requires identification of action plans and legislations, and developing databases, procedures and feedback systems to establish a holistic system. Finally, the implementation stage is composed of staffing, tendering and monitoring steps in which the results of PBMC are acquired.

Figure 1: Proposed strategic plan for PBMC

6 Conclusion

In this study, PBMC have been introduced and its specifics such as cost savings & financing, innovation, risk allocation, staffing, duration, contracting, quality & level of services and user satisfaction, tendering & political issues are discussed under the categories of characteristics and advantages, and challenges and drawbacks sections. To sum up, in the light of the arguments presented above, Turkey is expected to transfer to PBMC for road maintenance projects in the foreseeable future. In order to enable an effective transition, precedence should be given to developing legislations and setting performance indicators. For a solid initiation of PBMC, lessons learnt from other countries and pilot cases should be integrated. However, the utmost importance should be given to the restructuring of government organizations and guaranteeing a continuous funding for the lifecycle of the maintenance projects. Moreover, for the development of a new contracting system; a comprehensive, reliable

and transparent database should be created. Integrating such suggestions, a strategic plan is proposed and populated with exemplary suggestions. Although this study proposes a strategic plan by investigating the previous experiences of both developing and developed countries, it is not easy to directly implement this transfer. Hence, project specific data is required on the characteristics and outcomes of PBMC regarding issues such as geographical locations, durations, sizes from successfully implemented cases.

7 References

Ahmed, J., Gharaibeh, N., & Damnjanovic, I. (2012). Best-Value Bid Selection Methods for Performance-Based Roadway Maintenance Contracts. Journal of the Transportation Research Board, (2292), 12-19.

Anastasopoulos, P. C., McCullouch, B. G., Gkritza, K., Mannering, F. L., & Sinha, K. C. (2009). Cost savings analysis of performance-based contracts for highway maintenance operations. Journal of Infrastructure Systems, 16(4), 251-263.

Anastasopoulos, P. C., Florax, R. J., Labi, S., & Karlaftis, M. G. (2010a). Contracting in highway maintenance and rehabilitation: Are spatial effects important? Transportation Research Part A: Policy and Practice, 44(3).

Anastasopoulos, P. C., Labi, S., McCullouch, B. G., Karlaftis, M. G., & Moavenzadeh, F. (2010b). Influence of highway project characteristics on contract type selection: Empirical assessment. Journal of Infrastructure Systems, 16(4), 323-333.

Cabana, G., Liautaud, G., & Faiz, A. (1999). Areawide performance-based rehabilitation and maintenance contracts for low-volume roads. Journal of the Transportation Research Board, (1652), 128-137.

de la Garza, J.M., Pinero, J.C. and Ozbek, M.E. (2009), "A framework for monitoring performance-based road maintenance contracts", Proceedings of the Associated Schools of Construction45th Annual International Conference, Gainesville, FL, April 1-4, pp. 433-41

de la Garza, J., & Arcella, J. (2013). Current Performance-Based Maintenance Methods to Improve Virginia Highways: Comparative Analysis. Journal of the Transportation Research Board, (2361), 35-43.

EBRD (2016). Policy Challenges in the Implementation of Performance-based Contracting for Road Maintenance. European Bank for Reconstruction and Development.

Fuller, J., Brown, C. J., & Crowley, R. (2017). Performance-Based Maintenance Contracting in Florida: Evaluation by Surveys, Statistics, and Content Analysis. J. of Construction Eng. and Management, 144(2).

Gericke, B., Henning, T., & Greewood, I. (2014). Review of Performance Based Contracting in the Road Sector.

Haas, R., Felio, G., Lounis, Z., & Falls, L. C. (2009). Measurable performance indicators for roads: Canadian and International Practice. In Annual Conference of the Transportation Association of Canada, Vancouver.

Hardy, P. (2001). Austroads review of performance contracts: The potential benefits of performance contracts. Opus International Consultants, Nelson, 1-28.

Hyman, W. A. (2009). Performance-based contracting for maintenance (Vol. 389). Transportation Research Board National Research.

Madelin, K., & Parkman, C. C. (1999). A review of contract maintenance for roads. In Konferenzbeitrag, World Road Congress, World Road Association (PIARC), Paris.

Manion, M., & Tighe, S. (2007). Performance-specified maintenance contracts: Adding value through improved safety performance. Journal of the Transportation Research Board, (1990), 72-79.

Molenaar, K. R., & Yakowenko, G. (Eds.). (2007). Alternative project delivery, procurement, and contracting methods for highways. Reston: American Society of Civil Engineers.

Stankevich, N., Qureshi, N., & Queiroz, C. (2005). Performance-based contracting for preservation and improvement of road assets. Washington, DC: The World Bank.

Sultana, M. (2012a). The Potential of Performance Based Maintenance Contracting for Road Infrastructure Systems of Developing Countries. Thesis, Griffith University.

Sultana, M., Rahman, A., & Chowdhury, S. (2012b). Performance Based maintenance of road infrastructure by contracting—A challenge for developing countries. Journal of Service Science and Management, 5(02), 118.

Sultana, M., Rahman, A., & Chowdhury, S. (2013). A review of performance based maintenance of road infrastructure by contracting. Intern. Journal of Productivity and Performance Management, 62(3), 276-292.

Tamin, R. Z., Tamin, A. Z., & Marzuki, P. F. (2011). Performance based contract application opportunity and challenges in indonesian national roads management. Procedia Eng, 14, 851-858.

Wirahadikusumah, R., Susanti, B., Coffey, V., & Adighibe, C. (2015). Performance-based contracting for roads–experiences of Australia and Indonesia. Procedia Engineering, 125, 5-11.

Zietlow, G. (2004). Implementing performance-based road management and maintenance contracts in developing countries-an instrument of German technical cooperation. GTZ, Eschborn, Germany.

Zietlow, G. (2005). Cutting costs and improving quality through performance-based road management and maintenance contracts-the Latin American and OECD experiences. Senior Road Executives Programme, Restructuring Road Management, German Development Cooperation, Birmingham, UK.