POTENTIAL BARRIERS FOR ASSET MANAGEMENT SYSTEMS: A COMPARISON BETWEEN LIBYA AND SPAIN

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The goal of the research described in this paper is to investigate the obstacles and barriers that countries face during the development of an asset management system for infrastructures. Two countries are chosen for the analysis: Libya and Spain. Twenty-eight potential barriers are identified in the literature. A questionnaire survey is developed, calibrated and validated, taking into consideration these barriers. It is answered online by 58 practitioners from these two countries using a 5-point Likert scale. Twenty barriers have been recognized as important by both groups of practitioners. However, there are five obstacles that were determined important for Libya only and two that were important just for Spain. The findings enhance the understanding of these barriers and clarify rooted obstacles by considering different perspectives.

Keywords: *Asset Management; Barrier; Libya; Spain; Survey*

BARRERAS POTENCIALES PARA LOS SISTEMAS DE GESTIÓN DE ACTIVOS DE INFRAESTRUCTURAS: COMPARACIÓN ENTRE LIBIA Y ESPAÑA

El objetivo de la investigación descrita en el artículo es averiguar los obstáculos y barreras que afrontan los países durante el desarrollo de un sistema de gestión de activos de infraestructuras. Se han elegido dos países para el análisis: Libia y España. Se identifican 28 barreras potenciales en la literatura. Se desarrolla, calibra y valida una encuesta, considerando esas barreras previamente identificadas. Se obtuvieron 58 respuestas "on line" de profesionales de ambos países utilizando una escala Likert de cinco puntos. Ambos grupos de expertos han identificado veinte barreras importantes. No obstante, hay cinco obstáculo que fueron calificados como importantes sólo por los profesionales libios, y dos sólo por los españoles. Los hallazgos mejoran el entendimiento de estas barreras y sirven para clarificar los obstáculos existentes, considerando diferentes perspectivas.

Palabras clave: *Gestión de Activos de Infraestructuras; Barreras; Libia; España; Encuesta*

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1. Introduction

Infrastructure assets includes the facilities that provide essential public services of transportation, utilities (water, gas, electric,…), energy, telecommunications, waste disposal, park lands, sports, and recreational and housing, being the provider either public agencies or private companies (Uddin et al., 2013). The management of these infrastructure assets includes the whole life-cycle of the infrastructure, generally defined by five phases (Cleland, 1999): feasibility, design, construction, operation, and dismantlement. Asset management (AM henceforth) generally focuses more on the operation phase, specifically with maintenance and rehabilitation, in order to preserve and extend the long-term life-cycle of the infrastructure. Nonetheless, the construction phase is also very important because it is when the main investment is performed (Ashworth et al., 1984; Federal Highway Administration [FHWA], 2007b).

Therefore, managing infrastructure assets is essential, especially those in transportation (Uddin et al., 2013). They have to be managed properly and systematically due to the resources and expenditures required in both the construction and operation phases (Ashworth et al., 1984; FHWA, 2007b). Public demand is increasing, which puts more pressure on asset managers even in developed countries (Wijnia, 2009). For example, infrastructure managers in both United States and China are concerned about the future of their assets. The US needs to invest $3,6 trillion in different infrastructure sectors during this decade. Meanwhile, China has planned to double their expressway system from 45.000 km to 85.000 km by 2010.

AM supports managers during the critical steps, implementing systematic managerial processes. Since the 1990s, different developed countries have started looking for ways to improve the efficiency and effectiveness of their agencies' performance, in general, and safeguarding decision-making about their assets, in particular (TAC, 2001). For this research, the Federal Highway Administration (FHWA) definition for the AM that was published in 2007 is used: AM is a "decision-making framework guided by performance goals, cover[ing] an extended time horizon, draw[ing] from economics as well as engineering, and consider[ing] a broad range of assets" (FHWA, 2007a, p. 1).

Although AM provides procedures and tools to support organizations in operating their facilities efficiently and effectively (McNeil et al., 2000), most of the countries do not implement systematic processes for managing their assets (Alkilani & Jupp, 2012; Gwilliam, 2003; Heravi & Hajihosseini, 2011; Mushule & Kerali, 2001; Pinard, 1987; Sohail et al., 2002; Wijnia, 2009). It is important to understand any barriers to the establishment of an AM system. Therefore, this research aims to explore the obstacles that countries face during the establishment and implementation stages of an AM system, along with differences in specific countries' perspectives about AM. In the following section, the main characteristics of Libyan and Spain infrastructure assets, particularly transportation, are described. Next, the research method implemented in this study is explained. Then, the results are presented and analyzed, and conclusions are drawn.

2. Context

Libya is a developing country (World Bank, 2013) with a substantial roadway network—ranked 41/222—with about 100.000 km of paved and unpaved roads (Central Intelligence Agency [CIA], 2013). From the transportation mode perspective, Libyans do not have facilities to commute other than roads and personal cars. The public transportation is very limited and only between cities. The other mode of transportation is air travel; however, they are expensive for frequent use. Therefore, cars are still used more regularly.

Meanwhile, Spain has one of the largest roadway network in the world—ranked 10/222—with about 680.000 km of paved and unpaved roads (CIA, 2013). Spaniards use mainly highways and railways for transportations; some data from 2011 can substantiate this fact (Ministerio de Fomento, 2012): 31 million of vehicles (cars, trucks and buses), 2,900 million of travels by bus and subway, and 590 million of travels by train. Air transport is also very used: 200 million of travelers in 2011 (Ministerio de Fomento, 2012). The Spanish harbor system is very well developed too, having some of the most important harbors in the Mediterranean Sea (Barcelona and Valencia): 470 million of tons of goods were shipped through Spanish harbors (Ministerio de Fomento, 2012).

The similarity in the climatologic conditions between the two countries (both are on the Mediterranean Sea) limits the differences in the deterioration rates to management systems in both countries. Therefore, studying Spain alongside Libya is especially relevant. To generalize the findings from this research, the authors provide general characteristics for both countries. That will help other countries to compare their conditions.

The World Bank (2013) is used for definitions and information to identify developing countries, considering it is one of the most used and reliable sources of information about countries' economics. Libya can be identified as a developing country, whereas Spain can be identified as a developed economy (World Bank, 2013). Both countries have a large highway network; as the network increases, its needs for maintenance and rehabilitation become more complex and expensive. Both countries use air transportation too. The main difference between these two countries is the frequent use of metropolitan subway systems and railways in Spain, compared to Libya, as well as the importance of the harbor system in Spain, mainly for transportation of goods.

3. Research Method

3.1. Questionnaire Description

Questionnaires were administered to practitioners involved in decision-making processes from the two countries. The final questionnaire was composed of three sections: (1) management system experience; (2) obstacles that affect the AM system; and (3) personal information. The questionnaire started with the definition of an AM system; it introduced a simple framework for the systems' establishment and implementation processes. In the second section of the survey, 28 obstacles gleaned from literature, exploratory interviews, and the pilot surveys were presented under seven categories: (1) planning & decision making; (2) managerial & organizational; (3) information resources; (4) human resources; (5) financing resources; (6) social context; and (7) local knowledge.

Participants were asked to rate the effect of each obstacle on the establishing processes of the system, as displayed in Table 1. The type of questions included in the questionnaire demanded the use a 5-point Likert scale to quantify the responses. This scale is made up of items, which the respondent is asked to assess according to subjective criteria; in this case, the responses ranged from "very low" (1) to "very high" (5) effect; there was a neutral response (0) to indicate that the respondent had no idea about the effect. According to the data type, which is ordinal, responses to these questions are analyzed statistically by calculating their median.

3.2. Data Collection

At this point, the research can be considered exploratory; therefore, purposive sampling was conducted. In cases where the goal of the research is to approach a phenomenon, it is appropriate to purposefully choose individuals that get the most out of the primary phenomenon (Onwuegbuzie & Collins, 2007). The questionnaire survey was conducted from

June to September 2013, targeting practitioners from the two countries, in order to investigate their opinions about obstacles. One hundred and sixteen questionnaires were sent out and 68 were returned. Of those, 10 contained incomplete responses such as a lack of personal contact information or personal experience. The research team removed these responses from further analysis because of lack of reliability in the information. Only 58 responses were used for further steps of the research. In this case, the sample consists of 58 responses (29 from Libya and 29 from Spain) from infrastructure managers. The targeted respondents are project managers working for private developers (owners), concessionaire companies, or public organizations with experience in infrastructure management systems, not only highways, but also any kind of civil infrastructure such as water facilities, railways, harbors and airports. From Table 2, it is noticed that the higher participation is from managers who have more than 15 years of experience in the field (for both countries). This reduces any expected biases in the sample distribution.

Table 1: Rating scale definitions

CHOICE	MEANING
0	Do not know: No idea about its effect on this stage.
1	Very low effect: No extra time, no extra effort to overcome this obstacle.
2	Low effect
3	Moderate effect: Extra time, extra effort to overcome this obstacle.
4	High effect
5	Very high effect: Significant extra time, significant extra effort to overcome this obstacle.

3.3. Analysis Techniques

A descriptive statistical analysis is developed for this paper. The analysis procedures were designed based on two steps. First, the internal agreement was assessed among the respondents in each group separately by using the Kendall Concordance W test. The Kendall test guarantees the validity of the data for future analysis (Chan et al., 2009, 2010). In this test, the coefficient W was determined for each group by using the SPSS package. Based on the calculated p-value, a decision was made about the validity of the questionnaires' results for further analysis. If the p-value in any group is less than 0.05, that means the responses are statistically consistent and acceptable for further analysis. After this, the second assessment was used to investigate the mode for each obstacle. Any obstacle with two modes distributed on both sides of the moderate-effect category was ignored in further steps of the analysis because it reflected a conflict of the respondents' opinions.

Table 2: Practitioners' cumulative experience

Intervals in years	Libya	Spain
1-5	5	1
6-10	4	3
11-15	6	4
More than 15	14	21

4. Data Analysis

For this paper, the analysis focused on the internal agreement within each group. The obstacles will be discussed and presented according to the practitioners' assessments; as well as based on the categories that mentioned above for convenience and to simplify the discussion. Internal agreement in each group was tested by using the Kendall Concordance W test. This verified the validity of the survey for future analysis. Table 3 presents the Kendall coefficients of concordance W for the practitioners' rating of obstacles. Both p-values, which are 0.000, in each group indicated that there is a statistically significant consistence within the practitioners' opinions in each one. It is clear from the results that the data from the questionnaire is valid for further analysis.

Table 3: Kendall's W Test

Test Statistics	Libya	Spain
N	29	29
Kendall's W	0.144	0.154
Chi-Square	112.521	120.498
Df	27	27
Asymp. Sig.	0.000	0.000

Also, it is important to investigate the mode distribution for each obstacle. This explains the clarity of these obstacles to the practitioners through investigating their responses' patterns. As was explained earlier, any obstacle that shows extreme responses on different sides of the moderate effect will be removed from further analysis. This situation indicates that the practitioners held conflicting opinions. Therefore, these kinds of obstacles required more discussion and/or explanation about their meaning. Both groups present one mode in all responses for all the obstacles' assessments.

Meanwhile, based on the median values for the obstacles assessment, a comparison was made between the findings from the two groups. All the obstacles that were rated with "high" effect or higher on the establishment processes were isolated in the important range. Based on the above, the expected divisions for the obstacles are: important for both countries, important for Libya only, and important for Spain only. Any obstacle that does not fall into any of the previous divisions will be neglected from the further discussion.

5. Discussion of Results

This section discusses the barriers that have been considered important based on their effect on the AM system. They are presented under seven categories: (1) planning & decision making; (2) managerial & organizational; (3) information resources; (4) human resources; (5) financing resources; (6) social context; and (7) local knowledge. Twenty seven out of the 28 obstacles gathered from the initial exploration (literature review, exploratory interviews, and pilot surveys) were confirmed by the respondents as important. Twenty of them were confirmed in both countries, whereas seven of them only in one of the countries (five in Libya and two in Spain). The results are shown in Table 4 grouped by categories.

The first category is planning and decision making, which comprises four main barriers: lack of knowledge about stakeholders' needs, lack of strategic plans for organization, lack of identified processes and control procedures, and inconsistent decisions by the decision makers. Both countries agreed on these four barriers. Lack of knowledge about stakeholders' needs can be the first barrier and may be the most important one too (Shen et al., 2011). Most of the time, this barrier refers to misunderstanding about the real needs of the end users of the infrastructure. In flourishing economic times this can be translated into the construction of over-dimensioned facilities, mainly from the point of view of the aesthetics

that increase the budget as well as the costs of operation and maintenance of the infrastructure (Flyvbjerg et al., 2003). The users do not need that over-dimension, but the tax payers have to assume it.

Table 4: Barriers from Libya and Spain

BARRIERS	LYBIA	SPAIN
Category 1: Planning & Decision Making		
Lack of Knowledge about stakeholders' needs	X	X
Lack of strategic plans for organization	X	X
Lack of identified processes and control procedures	X	X
Inconsistent decisions by the decision makers	X	X
Category 2: Managerial & Organizational		
Lack of top management support	X	X
Poor management of the existing infrastructure	X	X
Lack of communication channels within organizations and departments	X	X
Lack of scope and job description within the organization/ agency	X	--
Lack of performance monitoring	X	--
Category 3: Information Resources		
Lack of data standard	X	X
Lack of data about the implemented phases of the plans	X	X
Lack of shared knowledge of asset management principles of systems across similar governmental units	X	X
Category 4: Human Resources		
Lack of knowledge transfer between consults (outsources) and local owners	X	X
Shortage of human resources	X	X
No trained staff	X	X
Category 5: Financing Resources		
Lack of recognizing budget constraints	X	X
Shortage of financial resources	X	X
Category 6: Social		
Departments unwilling to submit to overall framework	X	--
Resistance to change from local culture in the community	--	X
Category 7: Local Knowledge		
Using an incompatible operational process with local conditions	X	X
Lack of regulations to enhance the accountability	X	X
Lack of trust between different organizations and departments	X	X
Prevalence of corruption	X	X
Political participation interfering with project decisions	X	X
Undefined contracting criteria	X	--

BARRIERS	LYBIA	SPAIN
Centralized decision making	X	--
Using an incompatible technology with local conditions	--	X

Lack of strategic plans as well as identified control procedures means that the organization responsible for the infrastructure (either the developer or the manager) does not have proper managerial processes to run the infrastructure; this happens mainly for the operation phase. Another barrier, inconsistent decisions by the decision makers, is much related to the former two. When there is neither plan nor control, decisions made by the people in charge seem inconsistent (Smith, 1992). Sometimes, mainly when the developer is a public agency, politicians make decisions that should be made by project managers (de la Cruz et al., 2006). This discourages the work of the technicians (many of them civil servants); furthermore, the tax payers perceive that decisions are not made according to rational reasons.

Regarding the second category, managerial and organizational, five main barriers are detected: lack of top management support, poor management of the infrastructure, lack of communication channels within organizations and departments, lack of scope and job description within the organization or agency, and lack of performance monitoring. The last two were considered important only by the Libyan respondents, but not by the Spanish ones. This may be because Spanish organizations have more experience and they consider the scope, work description, and performance monitoring as a-matter-of-fact.

In any case, management support is vital for the success of the project. If the upper management of the organization does not consider the asset important for the organization, then this lack of support makes the whole system unfeasible (FHWA, 2007a; Hawkins & Smadi, 2013; Smith, 1992). Poor management may be a direct consequence of the former or, many times, will be a consequence of the indifference and negligence of the upper managers. Both groups emphasize the important of communication channels within organizations and departments. This obstacle effects the organizations' work quality and is considered as an essential element for the AM establishment failure (FHWA, 2007a; Kulkarni & Miller, 2003; Smith, 1992).

Another aspect is the information resource category, which also includes three additional barriers: lack of data standard, lack of data about the implemented phases of the plans, and lack of shared knowledge of asset management principles of systems across similar governmental units. Both countries agreed on these barriers. All of them are different ways of considering the inefficiencies of communication between the parties. Also, it explains the difficulties of finding and creating forms for the data to be transferred between different parties (Amekudzi et al., 2002; Cooksey et al., 2011).

Three other barriers appear regarding the human resources category: lack of knowledge transfer between outsources and local owners, shortage of human resources, and no trained staff. The first barrier links this category to the previous one (information) because the lack of knowledge between parties is due to a previous lack of information; therefore, the results are consistent on this matter and they highlight the role of knowledgeable staff (FHWA, 2007a). When the economy is booming, human resources are scarce and, when found, expensive and not well trained (that may not be the case of Spain nowadays but it was the real situation up to five years ago) (Villegas et al., 2012; Oviedo-Haito et al., 2014). In order to get the appropriate human resources, the organizations have to pay well and spend more money on training.

Regarding financial resources, there are two barriers in this category: lack of recognizing budget constraints and shortage of financial resources. Even though there are only two

barriers in this category, these two barriers are maybe the most important ones of the whole set. If there is a shortage of financial resources or there is no recognition of budgetary problems, then the feasibility of the infrastructure is in jeopardy (Alkilani & Jupp, 2012; Sharaf et al., 2008). If the infrastructure is still in the construction phase, then it may not enter into operation at all. If the infrastructure is in the operation phase, then it may degrade up to the point of being useless quickly (Vanier, 2001; Walker & Jones, 2012). Both countries support these findings.

The sixth category deals with the social environment in two obstacles: departments unwilling to submit to overall framework and resistance to change from local culture in the community. The first is backed by Libyans respondents. This selection may be related to the immatureness of the Libyan public administration because of the political instability of the country. Departments also refuse to change the work habits and environments that lead to failure of infrastructure management systems (FHWA, 2007a). On the other hand, the latter obstacle is supported by the Spanish experts. Resistance to change comes sometimes from different social groups' viewpoints, such as regional or local governments; this is a frequent issue in Spain.

Finally, the last category, local knowledge, comprises many barriers: using an incompatible operational process with local conditions, lack of regulations to enhance the accountability, lack of trust between different organizations and departments, prevalence of corruption, political participation interfering with project decisions, undefined contracting criteria, centralized decision making, and using an incompatible technology with local conditions. The first five barriers are common to both countries. Respondents encourage agencies to establish their AM systems based on minimum data requirements taking into account their conditions (Mushule & Kerali, 2001). Also, they highlighted the importance of the transparency and accountability in the work processes of the agencies. That should be enforced by regulations (Lord-Attivor & Jha, 2009). However, undefined contracting criteria and centralized decision making are supported by Libyan respondents. Both of these obstacles reduce the loyalty and responsibility of the employees for the AM success because these obstacles eliminate the involvement of wide range of the branches and staff in the decision-making processes (FHWA, 2007). Spain has a robust and consolidated public contract regulatory system, supported by the directives from the European Union; furthermore, decision-making is distributed among different public agencies such as regional and local governments. The use of incompatible technology with local conditions is supported by the Spanish experts; this may be because of the experience that many of the Spanish experts have working abroad, where this is usually one of the main barriers when a company comes from a developed economy to a developing country.

6. Conclusions and Limitations

The asset management (AM) systems respond to the need for a systematic procedure in developing and developed countries to manage their infrastructure assets properly. Although, AM systems promise these benefits, developed countries faced several obstacles in the establishing and implementing processes. In this paper, a survey was conducted in both Libya and Spain in order to investigate the effect of 28 potential obstacles, which were gleaned from the literature review, on the AM systems establishment and implementation processes. All the assessments for the internal agreement in each group showed that there are consistencies in the responses and clarity among the participants, respectively. These were approved by using the Kendall Concordance W test within each group separately. Also, the modes distributions were investigated in the responses for each obstacle in the groups.

This research clarifies developing countries' perspectives about obstacles to establishing the AM systems. Three categories included obstacles that were assessed differently based on

developed and developing countries. These were managerial/organizational, social, and local knowledge. This finding emphasize that the differences in the characteristics between the countries lead to different assessment for the same obstacles. Therefore, the processes for establishing and implementing AM systems should be changed and modified to match with the countries contexts.

The main limitation of this research is that the survey was exploratory and the sample chosen was purposive; even though outcomes cannot be generalized, this research does give insight from infrastructure asset managers of Libya and Spain. The factors obtained in this research should be tested and refined in the future with a larger number of managers. For future work, all obstacles that showed an agreement between the two groups about their effect on establishing AM systems (20 of them) should be explored through the Manny-Whiney test. Based on the theoretical concept of this test, in which the two groups have the same distribution and come from the same population (Siegel & Castellan, 1988), it has to be questioned whether there is a real agreement between the two groups about the effect of these obstacles. This will allow the findings to be presented with high confidence. These results also will be used as a basis for future research about AM establishment processes. Meanwhile, it will be worthwhile to investigate these obstacles in different contexts from both developed and developing economies to compare the findings and check their applicability. The research team is already working in a similar study in focused on the United States. This current and future research will help to generalize conclusions on AM systems.

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7. References

Alkilani, S., & Jupp, J. (2012). Paving the road for sustainable construction in developing countries: a study of the Jordanian construction industry. *Australasian Journal of Construction Economics and Building*, *1(1)*, 84-93.

Amekudzi, A., Herabat, P., Wang, S., and Lancaster, C. (2002). Multipurpose asset valuation for civil infrastructure: Aligning valuation approaches with asset management objectives and stakeholder interests. *Transportation Research Record*, *1812*, 211–218.

Ashworth, M., Hills, J., & Morris, N. (1984). *Public assets and liabilities and the presentation of budgetary policy. public finances in perspective*. London: The Institute for Fiscal Studies.

Chan, A.P.C., Lam, P.T.I., Chan, D.W.M., Cheung, E., & Ke, Y. (2010). Potential obstacles to successful implementation of public-private partnerships in Beijing and the Hong Kong special administrative region. *Journal of Management in Engineering*, *26(1)*, 30–40.

Chan, A.P.C., Lam, P.T.I., Chan, D.W.M., Cheung, E., & Ke, Y. (2009). Drivers for adopting public private partnerships. Empirical comparison between China and Hong Kong Special Administrative Region. *Journal of Construction Engineering and Management*, *135(11)*, 1115–1124.

CIA – Central Intelligence Agency (2013). *The world factbook*. Accessed on September 14, 2013, from https://www.cia.gov/library/publications/the-world-factbook/.

Cleland, D.I. (1999). *Project management. Strategic design and implementation*. New York: McGraw-Hill.

Cooksey, S.R., Seok, D.S., & Chae, M.J. (2011). Asset management assessment model for state departments of transportation. *Journal of Management in Engineering*, *27(3)*, 159–169.

De la Cruz, M.P., del Caño, A., and de la Cruz, E. (2006). Downside risks in construction projects developed by the civil service: the case of Spain. *Journal of Construction Engineering and Management*, *132(8)*, 844–852.

FHWA - Federal Highway Administration (2007a). *Asset management overview*. Washington DC: Federal Highway Administration.

FHWA - Federal Highway Administration (2007b). *US domestic scan program: Best practices in transportation asset management*. Washington DC: Federal Highway Administration.

Flyvbjerg, B., Bruzelius, N., & Rothengatter, W. (2003). *Megaprojects at risk: An anatomy of ambition*. Boston: Cambridge University Press.

Gwilliam, K. (2003). Urban transport in developing countries. *Transport Reviews*, *23(2)*, 197–216.

Hawkins, N., & Smadi, O. (2013). *Use of transportation asset management principles in state highway agencies. NCHRP synthesis of highway practice*. Washington DC: Transportation Research Board.

Heravi, G., & Hajihosseini, Z. (2011). Risk allocation in public—private partnership infrastructure projects in developing countries: a case study of the Tehran-Chalus toll road. *Journal of Infrastructure Systems*, *18*, 210-217.

Kulkarni, R. B., & Miller, R. W. (2003). Pavement management systems: Past, present, and future. *Transportation Research Record*, *1853*, 65–71.

Lord-Attivor, R., & Jha, C. (2009). The application of a transportation asset management program (TAMP) in Ghana. In: M. Jha, C. Long, N. Mastorakis, & C.A. Bulucea (Eds.), *Environmental Sciences and Sustainability* (pp. 142–150). Athens (Greece): WSEAS Press.

McNeil, S., Tischer, M.L., & De Blasio, A.J. (2000). Asset management: what is the fuss? *Transportation Research Record*, *1729*, 21–25.

Ministerio de Fomento (2012). *Anuario estadístico 2011*. Madrid: Ministerio de Fomento (in Spanish).

Mushule, N.K., & Kerali, H.R. (2001). Implementing of new highway management tools in developing countries: case study of Tanzania. *Transportation Research Record*, *1769*, 51–60.

Onwuegbuzie, A.J., & Collins, K.M.T. (2007). A typology of mixed methods sampling designs in social science research. *The Qualitative Report*, *12(2)*, 281-316.

Oviedo-Haito, R.J., Jimenez, J., Cardoso, F.F., & Pellicer, E. (2014). Survival factors for subcontractors in economic downturns. *Journal of Construction Engineering and Management*, *140(3)*, 04013056-1.

Pinard, M. (1987). Factors affecting the development and implementation of pavement management systems in developing countries. *2nd North American Pavement Management Conference*, pp. 1299-1310.

Sharaf, E.A., Abo-Hashema, M.A., & El-Hawwary, M.M.S.E.D. (2008). *A framework for pavement RL prediction using KDD*. New York: CRC Press.

Shen, L., Wu, Y., & Zhang, X. (2011). Key assessment indicators for the sustainability of infrastructure projects. *Journal of Construction Engineering and Management*, *137(6)*, 441–451.

Siegel, S., & Castellan, N.J. (1988). *Nonparametric statistics for the behavioral sciences*. New York: McGraw-Hill.

Smith, R. E. (1992). Addressing institutional barriers to implementing a PMS. In. F.B. Holt & W.L. Gramling (Eds.), *Pavement Management Implementation* (pp. 91-105). Philadelphia (PA): American Society for Testing and Materials.

Sohail, M., Miles, D.W.J., & Cotton, A.P. (2002). Developing monitoring indicators for urban micro contracts in South Asia. *International Journal of Project Management*, *20(8)*, 583–591.

TAC (2001). *Measuring and reporting highway asset value, condition and performance*. Vancouver: Transportation Association of Canada (TAC).

Uddin, W., Hudson, W., & Haas, R. (2013). *Public infrastructure asset management*. New York: McGraw Hill.

Vanier, D. (2001). Why industry needs asset management tools. *Journal of Computing in Civil Engineering*, *15(1)*, 35–43.

Villegas, L., Carrasco, C., Lombillo, I., Liaño, C., & Balbás, J. (2012). Construction in Spain: Crisis 2007-2010 and future prospects. *International Journal for Housing Science and Its Applications*, *36(2)*, 109-121.

Walker, R. G., & Jones, S. (2012). Reporting on infrastructure in Australia: Practices and management preferences. *Abacus*, *48(3)*, 387–413.

Wijnia, Y.C. (2009). Asset management for infrastructures in fast developing countries. *Infrastructure Systems and Services: Developing 21st Century Infrastructure Networks,(INFRA), 2009 2nd International Conference*, pp. 1–6.

World Bank (2013). *Middle East & North Africa (developing only) Data.* Accessed on , September 14, 2013, from http://data.worldbank.org/region/MNA?display=graph.