SUITABILITY OF CRITERIA FOR SELECTING A DELAY ANALYSIS TECHNIQUE SUITABLE TO ANALYSE DELAYS IN ROAD CONSTRUCTION PROJECTS IN SRI LANKA

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ABSTRACT

Delays in construction projects are inevitable and they are the most critical factor that affects the cost of a construction project. They have to be analyzed comprehensively using appropriate techniques so as to identify their impacts. This study was carried out to find out, the delay analysis techniques (DAT) that are used most commonly in road projects in Sri Lanka, the extent of their usage, problems that arises when they are used and the criteria for selecting a suitable technique. The research methodology adopted involved an extensive literature review, interviews and a questionnaire survey. The most commonly used DATSs were identified through the literature review and by interviewing four practitioners. A questionnaire survey was carried out among a group of 60 professionals selected through purposive sampling. It was found that five types of delay analysis techniques are mainly used in Sri Lanka to determine the delays encountered in road projects and the most commonly used such technique is the as-planned vs as-built analysis while the least used is the window analysis. The non-availability of professionals to analyze delays is found to be the main problem and acceptance by courts and tribunals is the most important criteria (out of nine identified criteria) used in selecting a delay analysis technique.

Keywords: *As-Planned vs As-Built Analysis; Criteria; Delay Analysis Techniques.*

1. INTRODUCTION

Delay analysis techniques are models or methods agreed upon by experts in projects subsequent to practical experiments (Keane and Calettka, 2008). In order to claim damages due to a delay, the cause of the delay and the party responsible for it should be identified correctly as delays could be due to various reasons and there could be several parties responsible for them (Arditi and Pattanakitchamroon, 2006). Menesi (2007) has added that, the complexity of a construction project could make the delay analysis process also complicated.

Perera (2006) has stated that 80% of road projects in Sri Lanka undergo time and cost overruns thus facing high risks in terms of cost and time. The root cause of a delay and the party responsible for it have to be identified through appropriate methods. It is therefore necessary to find out criteria through which an appropriate delay analysis technique suitable for road construction projects in Sri Lanka could be selected and the impact of the delays evaluated.

The aim of this study is to identify the criteria that can be considered in selecting a delay analysis technique to analyze the delays in road construction projects in Sri Lanka. With this aim, the following research objectives were formulated:

- Identification of various types of DATs and examination of their advantages and disadvantages
- Determination of the extent of application of DAT

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- Identification of the problems of applying DAT
- Identification of the criteria for selecting a DAT

2. LITERATURE REVIEW

2.1. DELAY ANALYSIS TECHNIQUES THAT ARE USED IN THE CONSTRUCTION INDUSTRY

Delay analysis techniques are available in the industry in various forms with different titles. Since each DAT could be used in numerous ways, they can be easily manipulated (Keane and Calettka, 2008). Yang *et al.* (2012) have emphasized that one of the most difficult tasks in certifying a claim in respect of delays is to identify the cause of the delays and their effect on the project completion date as the methods and procedures available to analyze the delays are insufficient. Further, they have described that in construction projects with complex project schedules, the analysis is time consuming and inaccurate. Mohammed and Jafar (2011) have stated that the complexity of construction projects is the main factor that influences the selection of an appropriate delay analysis technique.

2.2. TYPES OF DELAY ANALYSIS TECHNIQUES

Arcuri *et al.* (2007), Baker (2014), Braimah (2013), Barry (2009), Delay and Disruption Protocol (2002), Enhassi and Jubeh (2009), Francis *et al.* (2014), Hegazy (2012), Menesi (2007) and Ng *et al.* (2004) have stated that the most commonly applicable DTAs in the industry were as planned v as built, time impact analysis, window analysis, impacted as planned and collapsed as built. Yang and Kao (2009) had identified nine additional delay analysis techniques namely, adjusted as built, as built but for, as planned but for, as built critical path, global impact technique, net impact technique, linear schedule analysis, snapshot analysis and isolated delay types. Therefore by reviewing past research, it can be concluded that the most commonly used DATs are as 'as planned v as built', 'time impact analysis', 'impacted as planned', 'window analysis' and 'collapsed as built'. A brief description of frequently used techniques is given below:

- **As planned v as built-** Baker (2014) has defined as planned v as build method as one that initially identifies the critical path of a project in the as planned programme. Thereafter all the delays that occur during project execution are inserted in to the as built plan to identify the critical path of the as built plan. The time difference between the completion dates of as-planned and as-built is the extended period.
- **Impacted as planned**-This is a technique similar to the as planned v as built where the difference in delays is inserted in to the as planned programme in chronological order. The time difference between the two critical paths is the additional time needed (Baker, 2014).
- **Time Impact Analysis**- This method is an improvement to the as planned v as built method and also to the impacted as planned method where the programme is updated whenever there is a delay. The critical paths of the as planned and as built are compared with each other to identify the delay and the project completion date is thereafter forecast (Francis *et al.*, 2014).
- **Window analysis**-This is very similar to the time impact analysis where the difference in a set of delays within a selected time frame (window) is analyzed. The programme is updated by accommodating the variances. The delay is forecast after analyzing one window. At the end of the project the total amount of time entitlement is estimated Society of Construction Law (2002).
- **Collapsed as built (But for Test)-**This is a modification to the as planned v as built method in which the employer's delay is subtracted from the as built plan (as built but for). The claimant could have completed the project by this date, if not for the defendant's delay making it necessary to extend the date of completion by the relevant number of days (Francis *et al.*, 2014).

2.3. DELAY ANALYSIS PROCESS

Barry (2009) has argued that in analyzing delay claims it is important to look at the Effect and Cause and not at the Cause and Effect. Majerowicz (2001) was of the view that delay analysis procedure is a process in which the original schedule and the as built schedule are compared with each other to identify the variances. He has explained the delay analysis process as shown below:

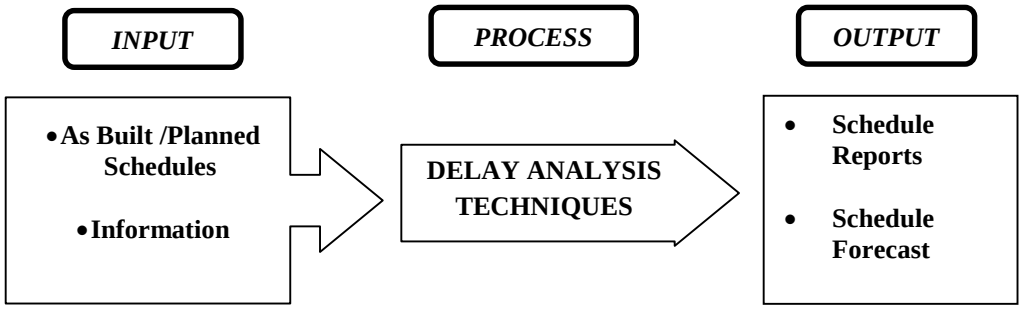

Figure 1: Delay Analysis Process

Figure 1 explains the delay analysis process consisting of an input process and an output process. Yang and Kao (2009) have stated that the identification of a suitable DAT is the first task to be considered by relevant parties before commencing the delay analysis process. They have further added that the selection of a suitable DAT will depend on factors such as the type of information available, time of analysis and the capabilities of the method, funds and effort. According to Hegazy (2012), delay analyzing procedures consist of Static Logic, Dynamic Logic, Model Methods, Addictive Methods and Subtractive Methods. The delay could however be agreed upon among the parties concerned but what would be the most difficult is to come to a compromise on the cost of the delay (Zack, 2002).

2.4. CAUSES FOR DELAYS IN ROAD CONSTRUCTION PROJECTS IN SRI LANKA

Lawrence (2002), has stated that the best way to resolve a dispute in construction projects is for the parties to have a good understanding. Arbitration and other dispute resolution processes are time consuming, costly and are a threat to the business relationship between the contractor and the client. Therefore identification of causes for delays and acting early to minimize their effects will be beneficial to all stakeholders of a project.

As the number of road projects undertaken is increased, the delays and associated costs would also increase (National Construction Association Sri Lanka, 2013). Poor preliminary planning, inaccurate budgets, unrealistic time allocations, imprecise contract clauses and late payments are the reasons for the delays. Wijenayake (2014) was of the view that the road construction projects in Sri Lanka are delayed due to issues related to land acquisition, improper designs, poor financial management, political interference, and environmental pollution. Variation orders have caused delays incurring high losses. (Halwatura and Ranasinghe, 2013). Jeyarajah and Jayawardena (2011) have confirmed these findings stating that during their construction stage, 56% of road construction projects in Sri Lanka are delayed due to variations in quantities. They have further stated that improper designs, changes in the scope and specifications are the other causes of delays .Pathiranage and Halwatura (2010) reveal that road construction projects in Sri Lanka are affected due to financial incapability's, poor site management, adverse weather, scope changes, delays in receiving instructions, lack of resources and external influences. Late payments, shifting of utilities, cost escalations, design changes and late site possession are also caused for delays (Wijekoon and Attanayake 2012).

2.5. IMPORTANCE OF IDENTIFYING A SUITABLE DAT FOR ROAD PROJECTS IN SRI LANKA

The timely intervention and applicability of relevant and reliable methods to analyze the delays in a construction project will pave the way for eradicating or minimizing the disputes between parties to a contract (Lawrance, 2002). Pathiranage and Halwatura (2010) have stated that 56% to 88% of road construction projects in Sri Lanka experience time overruns whilst Perera (2006) has stated that 80% of

road projects in Sri Lanka face the threat of time and cost overruns which in turn would have a bearing on the country's economy. The most vulnerable impact a construction delay can have for the country is for it to become a socio-economic problem (Wijekoon and Attanayake, 2012). A few professionals in Sri Lanka have attempted to resolve and manage accurately the delays in construction projects (Sudeha *et al.*, 2013). Most of them use ad hoc methods to evaluate the claims for time extensions which do not provide for estimating properly the actual impact of the delay on the project (Gunarathne, 2012). The accuracy of evaluating the delay claims is very low and consequently parties concerned have less confidence on the delay analysis processes used (National Construction Association of Sri Lanka, 2014). According to Priyantha *et al.* (2011), Sudeha *et al.* (2013), National Construction Association (2014), Halwatura and Ranasinghe (2013), Wijekoon and Attanayake (2012), Institute of Construction Training and Development (2008) and the Institute of Dispute Management Professionals (2013), the variations and cost overruns of road construction projects are on the rise. When there are variations in a contract, the contractor is entitled to claim for an extension of time and this it has to be evaluated accurately through an appropriate delay analysis technique. The failure to identify the party responsible for the delay will disrupt the construction process and their consequences will thus have to be borne by the public (Seboru and Atibu 2006). This is an area which has also not been adequately researched in Sri Lanka. Therefore, this research would emphasize the need to identify criteria for selecting appropriate delay analysis techniques for road construction projects in Sri Lanka.

3. RESEARCH METHODOLOGY

This descriptive study consists of three phases where primary and secondary data with qualitative and quantitative approaches were used. A comprehensive literature survey was carried out to identify various DATs used in road construction projects and their advantages and disadvantages. Interviews were conducted with four industry practitioners and a questionnaire survey was conducted to achieve the other objectives.

PHASE I: LITERATURE SURVEY

A comprehensive literature survey was carried out using peer reviewed journal articles, text books and periodicals (both print and electronic), theses and dissertations, reports, web pages, online publications and unpublished material. The literature survey helped to identify different delay analysis techniques that are used in the construction projects all over the world.

PHASE II: INTERVIEWS

Interviews were conducted with four professionals (practitioners) representing employers, consultants and contractors and who had experience in delay analysis techniques used in road construction projects in Sri Lanka refer table 1.

Table 1: Details of Interviewees

Details	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4
Profession	Engineer	Quantity Surveyor	Engineer	Engineer cum Lawyer
Designation	Project Director	Contract Specialist	Claims Specialist	Consultant
Experience (Years)	24	26	30	32

PHASE III: QUESTIONNAIRE SURVEY

Sixty questionnaires were distributed among professionals identified using purposive sampling technique and who were actively involved in delay analysis processes in road construction projects in Sri Lanka. Forty three of them responded to the survey.

3.1. DATA ANALYSIS

Data was verified completeness and accuracy by going through each questionnaire thoroughly and by running frequency distribution before being analyzed using SPSS data analyzing software. Frequency distribution was used to describe the extent of use of DATs in Sri Lanka. The data collected from the interviews was analyzed manually using grounded theory.

3.2. RELATIVE IMPORTANCE INDEX (RII)

The Relative Importance Index (RII) was used to rank the problems encountered in the application of DATs in Sri Lanka. It was also used to rank the criteria that are important in selecting a suitable DAT. The calculation of RII was done dividing the sum of weightings by the multiplication of the highest weight and the total number of respondents. Many researchers (Jeyamathan and Rameezdeen, 2006; Sumithiran, 2009; Sudeha *et al.*, 2013; Perera and Sudeha 2014) have identified RII as a data analysis technique for ranking the factors in identifying the most significant among them.

4. RESEARCH FINDINGS

4.1. TYPES OF DELAY ANALYSIS TECHNIQUES USED IN ROAD CONSTRUCTION PROJECTS

Five types of delay analysis techniques were identified in the literature recommended by the majority of authors. viz., Collapsed as built method, Window analysis method, As planned v as built method, Time impact analysis method and Impacted as planned method. The literature reveals that the techniques thus identified are used globally to analyze the delays in construction projects. The interviewees confirmed that the identified techniques are used to analyze the delays in road construction projects in Sri Lanka as well.

4.1.1. ADVANTAGES AND DISADVANTAGES OF THE IDENTIFIED TECHNIQUES

The advantages and disadvantages of the short listed techniques were identified in the second step of the first objective. As planned v as built and impacted as planned methods are simple, consume less time and are inexpensive. They are also very primitive and unreliable and could be easily manipulated and thus are not accepted by courts and tribunals. The Collapsed as built method is inexpensive, consumes less time, accommodates variations and is accepted by tribunals. Nevertheless it is also easy to manipulate and can analyze complex delays such as concurrent delays. Time impact analysis is reliable, accurate, difficult to manipulate and is accepted by tribunals. Furthermore, variations can be accommodated, contemporaneous updating is possible and the compensation can be categorized in terms of time and cost. However, it is expensive, complex, time consuming and need inputs from experts. Window analysis is also accurate, reliable, difficult to manipulate and is accepted by tribunals. Contemporaneous updating is possible and the compensation can be categorized in terms of time and cost. Yet, the accuracy can vary according to the selected time window and the set of delays within that window needs to be analyzed. This method is also expensive, time consuming and complex.

4.2. THE EXTENT OF APPLICATION OF DAT IN ROAD CONSTRUCTION PROJECTS IN SRI LANKA

The second objective of this study was to determine the extent of application of DAT in road construction projects in Sri Lanka. Participants were requested to give the following information on the projects in which they were involved:

1. Name of the project
2. Whether the project was delayed
3. Whether the contractor claimed an extension of time
4. Whether an extension of time was granted to the contractor
5. Whether DATs were used for analyzing delays and if so their details.

The name of the project was requested to avoid duplication. Based on the information provided by the respondents, forty eight (48) road construction projects whose contract values exceeded Rs. 500 million were identified. Table 2 below describes the extent of application of DATs in these forty eight (48) projects.

Table 2: Extent of Using DATS in Road Projects in Sri Lanka

	No of Projects	Percentage
Delayed	32	66.7
Not Delayed	16	33.3
DAT is Used	28	87.5
DAT is not Used	4	12.5
As Planned v As Built	15	53.6
Impacted As Planned	5	17.8
Window Analysis	2	7.2
Time Impact Analysis	3	10.7
Collapsed As Built	3	10.7

Two thirds (32/48, 66.7%) of the selected road projects were reported as delayed. The respective contractors have claimed extensions of time in all of them. It is interesting to observe that more than fifty percent of the projects which used DAT, had used as planned v as built to evaluate the delays. However, the literature survey revealed that the delay analysis techniques most used globally is the collapse as built and window analysis methods whereas in Sri Lanka they were the least used. The extent of the use of DAT to evaluate the delays is 87.5% and as planned v as built is the most commonly used (with 53.4%) DAT in road projects in Sri Lanka.

4.3. THE PROBLEMS IN APPLICATION OF DAT IN ROAD CONSTRUCTION PROJECTS IN SRI LANKA

Adjusting the organisational structure is one of the BIM strategies for the contractor. A BIM centre is separated from the former IT department. The problems that have an influence on the use of delay analysis as identified from the literature review and through interviews are as follows:

1. Small number of professionals involved in delay analysis
2. Use of ad hoc methods
3. Low accuracy in the evaluation of delay claims
4. Nonexistence of a requirement for delay analysis techniques to be mandatory
5. Preference given to backdoor settlements over others which are expensive and time consuming
6. Improper auditing of claims for extensions of time

These are listed in Table 3 which describes the importance of problems in the application of DATs in road construction projects in Sri Lanka as perceived by the study participants.

Table 3: Relative Importance of problems in the Application of DAT in Road Projects

Problems encountered in the application of DAT	**Employer/Consultant**		**Contractor**		**Overall**	
	RII	**Rank**	**RII**	**Rank**	**RII**	**Rank**
Shortage of professionals to analyze delays using DAT	0.704	1	0.658	1	0.684	1
Difficulty in collecting data for DAT	0.633	2	0.553	4	0.598	2
Lack of knowledge of the contractor on DAT	0.633	2	0.505	6	0.593	3
Lack of knowledge of the consultants on DAT	0.513	6	0.589	2	0.547	4
Poor reliability of the collected data	0.546	4	0.516	5	0.533	5
Lack of knowledge of the employer on DAT	0.530	5	0.463	7	0.500	6
Lack of facilities such as computers and software	0.388	7	0.558	3	0.463	7

According to Table 3, the shortage of professionals to analyze delays using DAT is the main problem (RII=0.684). Both the consultant/employer (RII=0.704) and the contractor (RII=0.658) have identified this as the main problem. It is interesting to observe that the consultant/ employer has ranked second the lack of knowledge of the contractor on DAT (RII=0.633) whereas the contractor has ranked second the lack of knowledge of the consultant on DAT (RII= 0.589). Consultant/ employer has identified difficulties in collecting data (RII=0.633, rank 2) and unreliability of collected data (RII=0.546, rank 4) as important problems in the application of DAT. Although the contractor has ranked the lack of facilities such as computers and software (RII=0.558) third, it has been ranked seventh by the consultant/ employer (RII=0.388). In the overall ranking (RII=0.463), it has been given a rank of 7 making it the last in the ranking.

4.4. IDENTIFICATION OF THE CRITERIA FOR SELECTING A SUITABLE DELAY ANALYSIS TECHNIQUE IN ROAD CONSTRUCTION PROJECTS IN SRI LANKA

According to the literature review, the selection of a suitable delay analysis technique will depend on cost, time, accuracy, acceptability by courts and tribunals, reliability and complexity. During the interviews two other factors were also identified viz., the workability (contemporaneous) and acceptance by the parties concerned. Nine scenarios/ criteria identified in the literature and through the interviews are listed in Table 4. Through the questionnaire survey, the relative importance of these criteria was identified using a 10 point scale as described in Table 4.

Table 4: Importance of the Criteria for Selecting a Suitable DAT

Criteria that have to be considered in selecting a DAT	RII	Rank
Acceptability by courts and tribunals	0.953	1
Acceptability by relevant parties	0.886	2
Accuracy of the technique	0.828	3
Complexity of the analysis	0.781	4
Reliability of the technique	0.779	5
Inputs of experts	0.756	6
Workability of the technique	0.619	7
Cost of the analysis	0.488	8
Time taken for the analysis	0.477	9

According to Table 4, the acceptability by tribunals and courts has scored a RII value of 0.953 becoming the highest ranked and becoming the most important criteria to be considered in the selection of a suitable DAT. Acceptability by parties to the contract and the accuracy of the technique have been ranked second and third respectively scoring RII values of 0.886 and 0.828 respectively. The complexity of the analysis, reliability, inputs of the experts and the workability remain at moderate levels. According to the respondents, the cost and time of analysis are of low importance with their RII values being the lowest (0.488 and 0.477 respectively).

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. CONCLUSIONS

The delay analysis techniques available globally and their advantages and disadvantages were found through a comprehensive literature review. Consequently, fourteen delay analysis techniques were identified and the five techniques that are mostly used were: as planned v as built, impacted as planned, collapsed as built, window analysis and time impact analysis. Then the extent of use of DAT in road construction projects in Sri Lanka was found. Accordingly, the extent of use of DAT to evaluate the delays in the projects concerned was 87.5%. The as planned v as built method was the most used DAT. The order of use of the DATs is as planned v as built, impacted as planned, time impact analysis, collapsed as built, and window analysis.

Afterward, using the literature review, questionnaire survey and interviews, the problems of DAT when used in road construction projects in Sri Lanka were identified. The analysis revealed that the shortage of professionals to analyze time extensions using DAT is the main problem. However, the non-availability of computer software, accessories and other equipment was not a major problem in the delay analysis. The delay analysis techniques being not specified in contracts, the use of ad hoc methods by the parties concerned was identified as other critical problems. Finally, the criteria for selecting a DAT for road construction projects in Sri Lanka using literature review, interviews and questionnaire survey was identified. Accordingly, time taken for the analysis, cost, inputs required from experts, complexity, reliability, accuracy, acceptability by the tribunals and courts, acceptability by the parties to the contract and workability are the important criteria to be considered in selecting a DAT. The acceptability of the DAT by courts and tribunals is the most important criteria while the cost and time are the least important criteria.

5.2. RECOMMENDATIONS

The research reveals that there is a shortage of professionals to analyse delays in road construction projects in Sri Lanka and that the most important criteria is generally ignored in selecting a DAT. Therefore, it is recommended to increase the number of professionals who can use DAT and select an appropriate technique for the delay analysis. When a DAT is selected it is important to ensure that the selected technique is accepted by courts and tribunals. It is also important to introduce a pay item in the bill of quantities (BOQ) to recover the cost that is incurred in using delay analysis.

6. REFERENCES

Arcuri, F.J., Hildreth, J.C. and Tech, V., 2007. *The Principles of Scheduling Impact Analysis* (TR-07-03).Virginia, United States: Virginia Polytechnic Institute and State University.

Arditi, D. and Pattanakitchamroon, T., 2006. Selecting a Delay Analysis Method in Resolving Construction Claims. *International Journal of Project Management*, 24, 145-155.

Baker, K.R., 2014. *Presenting Delay Claims: Where is the Logic?* [online]. Available from: https://twiter.com/LormanEducation [Accessed 15 November 2014].

Barry, D., 2009. Beware of the Dark Arts Delay Analysis and the Problems with Reliance on Technology. In: *Society of Construction Law International Conference* [online], London. Available from: www.scl.org.uk [Accessed 10 November 2014].

Braimah, N., 2013. *Construction Delay Analysis Techniques* [online]. Available from: www.mdpi.com/journal/buildings [Accessed 07 December 2014].

Enshassi, A. and Jubeh, A., 2009. Delay Analysis Methods and Factors Affecting their Selection in the Construction Industry in Gaza Strip [online]. *Journal of Financial Management of Property and Construction*, 14(2), 126-151. Available from: http://dx.doi.org/10.1108/13664380910977592 [Accessed 08 December 2014].

Francis, J., Brennan, P.E., Michael, F. and D'Onofrio, P.E., 2014. *Techniques and Models for Assessing Delays* [online]. Available from: www.cpmiteam.com/Assessing Delays.html [Accessed 12 November 2014].

Gunarathne, Y.M.S.B., 2012. *Factors Affecting for Selection of Suitable Delay Analysis Technique for Sri Lankan Construction Industry*. Dissertation (BSc.). University of Moratuwa.

Halwatura, R.U. and Ranasinghe, N.P.N.P., 2013. Causes of Variation Orders in Road Construction Projects in Sri Lanka. *Journal of ISRN Construction Engineering* [online], 1-7. Available from: http://dx.doi.org/10.1155/2013/3816170 [Accessed 04 November 2014].

Hegazy, S., 2012. Delay analysis methodology in UAE Construction Projects. *PM World Journal* [online], 1(2), 1-17. Available from: www.pmworldjournal.net [Accessed 29 December 2014].

Institute of Construction Training and Development, 2008. *Sri Lanka Country Report* [online]. Available from: www.ictad.lk [Accessed 11 November 2014].

Institute of Dispute Management Professionals, 2013. *Dispute Management* [online]. Available from: http://www.idmp.lk/ [Accessed 10 November 2014].

Jeyakanthan, J. and Jayawardane, A.K.W., 2012. Mitigating Project Delays in Donor Funded Road Projects in Sri Lanka. *Journal of the IESL*, 45(1).

Jeyakanthan, J. and Rameezdeen, R., 2006. Skills and Competencies of Quantity Surveyors: The Case of Sri Lanka. In: Rameezdeen, R. and Senevirathne, I., eds. *Customizing the Quantity Surveyor to Face the Challenges in Year 2020*, Department of Building Economics, Moratuwa. 9-18.

Keane, P.J. and Calettka, A.F., 2008 .*Delay Analysis in Construction Contract*. United Kingdom: Blackwell Publishing Ltd.

Lawrance, G.H., 2002. Objectifying Claims on Extension of Time in Construction Contracts. *Journal of Institute of Engineers Sri Lanka*, 37(2).

Majerowiz, W., 2001. Schedule Analysis Techniques. In: *13th Annual International Integrated Programme, Management Conference.*

Menesi, W., 2007. *Construction Delays Analysis under Multiple Baseline Updates* [online]. Thesis (M.Sc.). University of Waterloo. Available from: http://www.scribd.com/doc/59763547 [Accessed 02 November 2014].

Mohammed, S.R. and Jafar, S.S., 2011. Construction Delay Analysis using Daily Window Technique. *Journal of Engineering*, 1(17), 186-198.

National Construction Association of Sri Lanka, 2014. *Report on Payment Delays in Sri Lankan Construction Industry.*

National Procurement Agency, 2006. *Procurement Guidelines* [online]. Available from: www.treasury.gov.lk [Accessed 02 November 2014].

Ng, S.T., Skitmore, R.M., Deng, M.Z.M. and Nadeem, A., 2004. Improving Existing Delay Analysis Techniques for the Establishment of Delay Liabilities. *Journal of Construction Innovation: Information* [online], *Process, Management*, 4(1), 3-17. Available from: http://eprints.qut.edu.au/archive/00004116 [Accessed 12 November 2014].

Pathiranage, Y.L. and Halwatura, R.U., 2010. *Factors Influencing the Duration of Road Construction Projects in Sri Lanka* [online]. Available from: http://dl.lib.mrt.ac.lk [Accessed 02 November 2014].

Perera, B.A.K.S. and Sudeha, H.M.C.K., 2014. Framework to Select the Most Suitable Delay Analysis Technique for Building Construction through a Consideration of Utility Factors. *Bhoomi the Planning Research Journal*, 3(2).

Perera, K.B.D., 2006. *Simulation Modeling for Time and Cost Overrun in Road Rehabilitation Projects in Sri Lanka.* Dissertation (BSc.). University of Moratuwa.

Priyantha, T.H.S., Karunasena, G. and Rodrigo, V.A.K., 2011. Causes, Nature and Effects of Variations in Highways. *Built Environment - Sri Lanka*, 1(2), 14-15.

Seboru, A. M., 2006. *An Investigation into Factors Causing Delays in Road Construction Projects in Kenya* [online]. Available from: http://www.uonbi.ac.ke/)www.textroad.com [Accessed 11 November 2014].

Rider of Construction Law, 2002. *Delay and Disruption Protocol* [online]. Available from: http://www.scl.org.uk/resources [Accessed 10 December 2014].

Sudeha, H.M.C.K., Perera, B.A.K.S. and Illankoon, I.M.C.S., 2013. *Utility Factors Affecting for Selecting Delay Analysis Technique.* In: Senevirathne, L.D.I.P and Sandanayake Y. G., eds. *Second World Construction Symposium on Planning, Designing and Building for Tomorrow*, Sri Lanka. 473-482.

Sumithiran, Y., 2009. *A Mature Profession of Quantity Surveying in Sri Lanka*. Dissertation (BSc.). University of Moratuwa.

Wijekoon, S.B. and Attanayake, A.M.C.T.K., 2012. *Study on the Cost Overruns in Road Construction Projects in Sri Lanka* [online]. Available from: http://dl.lib.mrt.ac.lk [Accessed 11 December 2014].

Wijenayake, T., 2014. *Delays and Escalating Cost in Road Construction* [online]. Available from: http://www.ftlk [Accessed 08 December 2014].

Yang, J. B., Huang, K. M., Chen, C.M. and Liu, S.H., 2012. Implementing Schedule Delay Analysis Methodology on Project Management System. In: *14th International Conference in Computing in Civil and Building Engineering*, Moscow, Russia.

Yang, J.B. and Kao, C.K., 2009. Review Delay Analysis Methods: A Process Based Comparison. *The Open Construction and Building Technology Journal*, 3, 81-89.

Zack, J.G., 2002. Calculation and Recovery of Home/Head Office Overheads. *Journal of Cost Engineering Council*, 1-4.