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Factors affecting road construction project performance in Addis Ababa, Ethiopia

Mekonnen Tibebu CHEKOL[1]*, Michael HENRY[2]

[1] *Graduate School of Engineering and Science, Shibaura Institute of Technology, Tokyo, Japan, E-mail address: na22503@shibaura-it.ac.jp*
[2] *Department of Civil Engineering, Shibaura Institute of Technology, Tokyo, Japan. E-mail address: mwhenry@shibaura-it.ac.jp*

Abstract: Addis Ababa, the capital of Ethiopia, has been lacking an adequate road network to ensure community access to social, political, and economic resources and to facilitate economic development. The road network coverage was about 22.5% in 2022, which is below the minimum international standard of 25%. To improve accessibility and mobility, the Addis Ababa City Roads Authority (AACRA) has engaged its own force crew (contractor), as well as local and foreign road contractors, in the construction of urban roads. However, these road construction projects are rarely completed within the estimated time and cost, along with a variety of other issues that also need to be addressed. This study aims to explore the application of lean construction for improving the performance of urban road construction projects in Addis Ababa City. A survey of road construction stakeholders was carried out to evaluate their perspectives on the importance of project performance indicators, with the goal of identifying key factors affecting road construction project performance. First, a list of performance indicators was prepared based on a review of lean construction literature, and a total of 38 identified factors were grouped into six performance indicator categories. Cross-tabulation analysis of the stakeholder perspectives was then carried out, and it was found that the indicators that affect the performance of urban road infrastructure projects (in descending order of importance) were: time, quality, cost, risk, safety, and sustainability. Through this analysis it was concluded that right-of-way issues, delay to finish, inflation, contractor capacity, and scope change with change order are also major factors that affect the performance of urban roads construction projects. Clarification of these factors will provide AACRA with useful information on what aspects of lean construction should be prioritized when evaluating future construction projects.

Key words: Lean construction, Project performance, Road construction, Stakeholder perspectives

1. INTRODUCTION

In developing countries, the construction industry employs about 20% of the workforce and covers about 30% of the capital budget of governments [1]. Road construction projects are often complicated and require man power, machinery and technical as well as financial capacity, which may be lacking in some developing countries. These requirements are even more important in the case of urban road construction due to the additional challenges of carrying out projects in urban areas, such as right-of-way problems, utility relocation, high traffic volume, and complex stakeholder issues, as well as financial and technical capacity issues are the major ones [2].

Construction is one of the major economic sectors of Ethiopia, which constitutes 6% to 9% of gross domestic product (GDP) and about half of the fixed capital formation. In the capitol of Ethiopia, Addis Ababa, the road network coverage grew from around 18.5% in 2013 to 22.5% in 2022 [3], but is still less than the minimum international standard. The effort to attain this standard is highly challenged by the challenges of urban road construction faced in Addis Ababa, such as access issues, right-of-way problems, high traffic volume, and complex stakeholder issues, as well as financial and technical

capacity issues, all of which have a huge negative impact on road construction projects in Addis Ababa city. As a result, many projects face cost overrun and time delay because of the limitation of stakeholders to overcome these problems. A performance evaluation from the Addis Ababa City Road Authority (AACRA) for 12 on-going construction projects (4 from own force and 8 from out-sourced projects) revealed that; only 2 projects were successful, 6 somewhat successful and the remaining four were unsuccessful. Criteria weights for this evaluation were Relevance (10%), Effectiveness (30%), Efficiency (30%), Outcome (10%), Impact (10%), and Sustainability (10%). The report identified the main challenges as right-of-way acquisition, traditional project management, consultant and contractor capacity, design change, and stack holder management [4]. Other challenges include limited resources and environmental impacts related to poor energy and waste management. Those challenges are also a source of construction wastes (non-value adding activities). It has been found that 30% to 40% of construction time is lost to non-value adding activities, such as overproduction and waiting-related wastes[8]. Managing and reducing wastes related to construction processes can save disposal and and transport costs, save time, increase profit, protect the environment, and create a clean and safe work site [5-8]. Thus, it is important to assess the major factors affecting the performance of urban road construction to identify possible solutions to successfully manage projects with regards to time, cost, quality and safety requirements, together with acting in a socially, politically, and environmentally acceptable manner [9]. The objective of this research is to identify factors affecting the performance and propose methodology to improve the performance of urban projects in Addis Ababa, Ethiopia.

2. LEAN CONSTRUCTION

Lean construction (LC) is one effective management tool for improving efficiency in the field of urban road construction. It is a management philosophy that combines waste elimination, continuous improvement, availability of resource, team work and supply chain management [10]. There are five basic principles: identifying the values of from the perspective of stakeholder, recognizing value stream mapping based, removal of waste by various processes which influence work flow process, creation of a system of pull production to ensure just in time delivery to the customer, and finally achieving continuous improvement and pursuing perfection [10,11]. LC is concerned with concurrent and continuous improvement in the life cycle of road projects, from design and construction to maintenance and demolition [7]. It helps in identifying the root causes of wastes, eliminating those causes with appropriate tools and techniques, and encourages prevention of waste, rather than reactive actions [11]. In principle, for urban road project performance improvement, wastes should be minimized or avoided [12], and creating project value may help eliminate waste in lean design and construction [9]. Generally, the most frequent types of wastes in construction are defect (rework), over production, waiting, non-utilized talent, transport, inventory, motion, and over processing [11,13]. A number of lean tools and techniques are currently used in road projects, the most frequent of which are listed in Table 1.

Table 1. Lean Construction tools

Lean Construction tools	Description
Last planner System (LPS)	Minimizes the project uncertainty by planning backwards from a target and increases the commitment of members involved with the project flow and variables
Integrated Project Delivery (IPD)	Construction delivery method by which key parties are involved and join in design and construction aspects of a project under a single agreement
Building Information Model (BIM)	A detail visual model to identify potential problems during planning
5s **(**Sort, Straighten, Shine, Standardize,and Sustain)	Workplace management tools for safe, clean, well organized, and quality work environment, both mentally and physically
Kaizen	A continuous improvement tools to improve safety, productivity, quality and workplace culture and to make processes, methods, and practices as accurate, efficient, and effective as possible.

3. METHODOLOGY

3.1 Survey content

A questionnaire survey was developed from literature review and disseminated for a quantitative research approach [9,17,18]. Forty four (44) variables related to factors affecting the performance of urban road projects and performance indicators were derived from an extensive literature review. The variables were then separated into two classifications: performance indicators variables (6 variables) that contribute to the evaluation of urban road project performance, and performance affecting variables (38 variables) that affect the performance of urban road projects. The same categories of variables in each group were then clustered into the same categories. Performance indicator variables were grouped into the six indicator categories: cost, time, quality, safety, sustainability, and risk.

The survey was designed to clarify the perception of road project stakeholders with regards to the characteristics of performance indicator during the construction, maintenance, and management performance evaluation process, and the questionnaire contained questions relating to the importance of the performance indicators in the evaluation of road project performance, the degree to which the factors affect the performance of urban road projects, and the degree to which non value-adding activities affect road projects. Respondents were asked to evaluate importance using a five-point Likert scale: (1) very unimportant; (2) somewhat unimportant; (3) neither important nor unimportant; (4) somewhat important; (5) very important. To evaluate the effect of the factors on road project performance, respondents were provided with a five-point scale from 1 (not at all) to 5 (to a very large extent). The other section dealt with the severity of non-value adding activities (wastes). Each respondent was asked to rate the severity level of non-value-adding activities to construction performances on a five-point scale from 1 (insignificant) to 5 (severe). Analysis of the survey responses were carried out using the mean values to identify the different perceptions of respondents towards the three research topics.

3.2 Profile of respondents

The survey was carried out targeting AACRA stakeholders who are responsible for the Addis Ababa city road projects planning, construction, maintenance, and management, which includes the client-side (AACRA staff), contractors, and consultants. A total of 65 completed questionnaires were returned from 75 respondents, representing a response rate of 86.7%. The profiles of the respondents working in different organization, departments or directorates and their experience in the road sector are presented in Table 2.

Table 2. Distribution of respondents in organization

Organization	**No. of respondents**	**Response rate (%)**
Client(AACRA staffs)	52	80%
Consultants	7	11%
Contractors	6	9%
Department/Directorate	**No. of respondents**	**Response rate (%)**
Design and Procurement (D&P)	11	16.9%
Planning and Control (P&C)	11	16.9%
Construction and Site management (C&S)	40	61.5%
Health and Safety (H&S)	3	4.6%
Experience in Road Sector	**No. of respondents**	**Response rate (%)**
5 years or less	8	12%
6-10 years	27	42%
11-15 years	17	26%
16-20 years	10	15%
20 years or more	3	5%

4. RESULTS AND DISCUSSION

4.1 Importance of indicators for performance evaluation

Table 3 shows the ranking of performance indicators for urban road projects as established in this research. From this results, it was revealed that time performance indicators are the most important in evaluation of urban road project performance in Addis Ababa, Ethiopia. As the road projects were targeted to address complex stakeholder issues, such as high traffic volume and urbanization, time performance of construction and maintenance projects is very crucial and a dominant performance indicator for road projects. Time performance indicators was ranked highest mean value (4.631), Quality performance indicators were ranked second mean value (4.569), followed by cost performance indicators with mean value (4.415), safety performance indicator with mean value (4.323), sustainability performance indicators with mean value (4.154) and risk performance indicator with mean value (4.123).

Table 3. Ranking of performance indicators

Performance Indicators	Mean Values	Standard deviation	Rank
Cost Performance	4.415	0.967	3
Time Performance	4.631	0.961	1
Quality performance	4.569	1.000	2
Safety Performance	4.323	1.047	4
Sustainability performance	4.154	0.988	5
Risk performance	4.123	0.976	6

4.2 Correlation between performance indicators

Pearson correlation assesses how much one variable changes when the other variable changes. The correlations between the six indicators are presented Table 4. A strong correlation was observed between safety and quality (0.830), which implies that quality performance and safety performance of road projects may have a relationship.

Table 4. Pearson Correlation Coefficient

Indicators	Cost	Time	Quality	Safety	Sustainability	Risk
Cost	1					
Time	0.678	1				
Quality	0.671	0.733	1			
Safety	0.488	0.645	0.830	1		
Sustainability	0.490	0.616	0.712	0.684	1	
Risk	0.389	0.535	0.602	0.684	0.650	1

4.3 Degree to which factors affect project performance

Table 5 to Table 10 present the rankings of factors affecting the performance of urban road projects. Out of all the factors affecting the performance of urban road projects, it was revealed that the time performance factor “right-of-way acquisition issues” were judged to have the highest effect on the performance of urban road projects.

Table 5. Rank of Cost factors

C	Cost	Mean Value	Standard deviation	Rank
C1	Design change	3.800	0.922	2
C2	Inflation	4.369	0.651	1
C3	Incomplete design and Specification	3.631	0.977	4
C4	Scope change with change order	3.600	0.915	5
C5	Project Performance monitoring	3.723	1.281	3

Table 6. Rank of Time factors

T	Time	Mean Value	Standard deviation	Rank
T1	Delay to finish	4.569	0.661	2
T2	Project management and Coordination	4.031	0.883	4
T3	Right-of-way acquisition issues	4.800	0.403	1
T4	Financial problems	3.954	1.096	5
T5	Delayed payment	3.400	1.157	6
T6	Contract dispute	3.015	1.008	7
T7	Utility relocation	4.046	0.926	3

Table 7. Rank of Quality factors

Q	Quality	Mean Value	Standard deviation	Rank
Q1	Contractor capacity	4.292	0.931	1
Q2	Project site management and supervision	3.892	0.753	3
Q3	Quality of material and equipment used	3.985	1.023	2
Q4	Conformance to specifications	3.815	0.967	6
Q5	Project management skills	3.892	0.886	3
Q6	Capability of owners	3.877	1.008	5

Table 8. Rank of safety factors

S	Safety	Mean Value	Standard deviation	Rank
S1	Worker Safety	3.908	1.042	1
S2	Traffic safety	3.785	0.96	2
S3	Environmental safety	3.569	0.935	3
S4	Communication safety	3.246	0.936	6
S5	Training and education	3.431	1.030	4
S6	Health and regulations	3.431	1.045	4

Table 9. Rank of Sustainability factors

Su	Sustainability	Mean Value	Standard deviation	Rank
Su1	Impact to local ecosystem	3.262	1.108	5
Su3	Contribution to climate change	3.046	1.152	6
Su3	Air quality	2.769	1.072	8
Su4	Water quality	2.738	1.050	9
Su5	Resource usage efficiency	3.585	0.983	1
Su6	Waste generation	3.323	0.954	4
Su7	Stakeholder satisfaction	3.554	1.016	2
Su8	Public health	3.031	1.060	7
Su9	Economic viability	3.492	1.002	3

Table10. Rank of risk factors

R	Risk Performance Indicators	Mean Value	Standard deviation	Rank
R1	Political risk	3.862	1.130	1
R2	Technical risk	3.569	1.045	2
R3	Social risks	3.354	1.022	3
R4	Environmental risks	3.138	1.044	5
R5	Legal Risks	3.323	1.062	4

4.4 Most influential factors affecting project performance

The five most influential factors affecting the performance of urban road projects, as revealed in the preceding analysis on the degree to which factors affect the performance of urban road projects, are presented in Table 11. These five factors affect the overall performance of the urban road projects due to their influence on the three basic constraints of project management [19]. The negative coefficients of the regression analysis revealed an inverse effect from a unit change of factors on the project performance, while the positive coefficients revealed a positive effect from a unit change of factors to the project performance.

Table 11. Most influential factors

S/No.	Performance Indicators	Performance affecting factors	Regression Coefficient	Mean Value	Overall Rank
T3	Time	Right-of-way acquisition issues	-0.388	4.800	1
T1	Time	Delay to finish	-0.010	4.569	2
C2	Cost	Inflation	-0.322	4.369	3
Q1	Quality	Contractor capacity	0.158	4.292	4
C4	Cost	Scope change with change order	0.153	3.600	5

4.5 Chi-square test of association

The chi-square test for association was carried out to examine the relationship between the type of respondents (client, contractor, and consultant) and their perspective on the performance indicators. The null hypothesis was that there was no significant association between the respondent type and performance indicators (ho), and the alternative hypothesis was that there was an association (ha). As shown in Table 12 except for the risk performance indicators, the null hypothesis accepted for the rest which means that no significant association exists between the respondent type and the importance of the performance indicators for evaluating urban road project performance.

Table 12. Results of chi-square test between respondent type and indicator importance

Performance Indicators	Chi-Square	Level of significance (p-value)	Accept Ho if $\alpha \geq 0.05$
Cost	11.14	0.194	Accepted
Time	12.39	0.135	Accepted
Quality	8.65	0.070	Accepted
Safety	8.34	0.214	Accepted
Sustainability	13.608	0.087	Accepted
Risk	21.204	0.007	Rejected

4.6 Perception of current project performance issues

The satisfaction of the respondents with the current performance of road projects are summarized in Figure 1. It showed that 2.9% were very satisfied which revealed there has to be improvement methodology to increase the level of satisfaction of respondents.

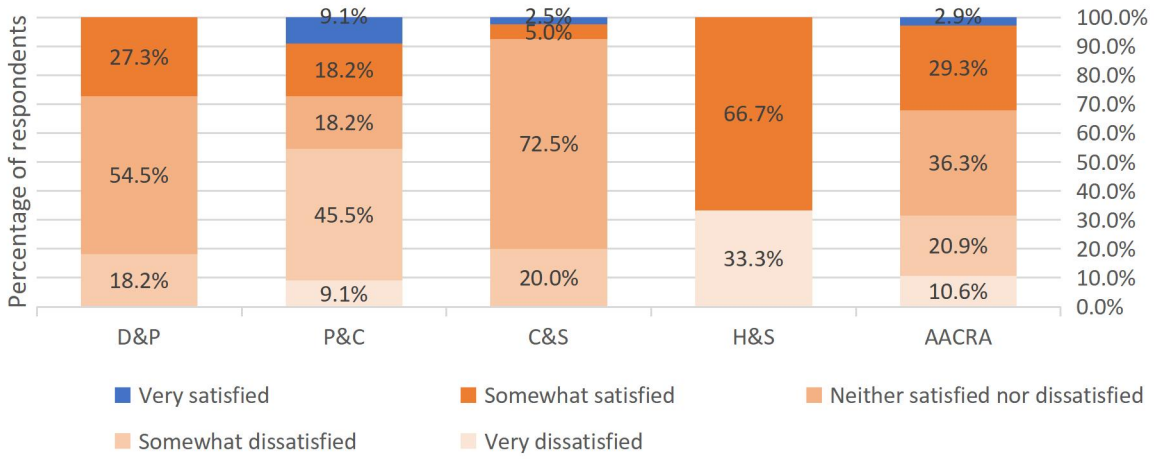

Figure 1. Respondent satisfaction with current road project performance

The perspectives of respondents on the severity of non-value adding activities are presented in Table 2. Defects and waiting have the highest percentage of respondents who saw these as severe issues. Clarifying the severity of these non-value adding activities will enable AACRA to identify causes and find solutions to improve the satisfaction with urban road project performance.

Figure 2. Perspectives of respondents ob the severity of non-value adding activities

5. CONCLUSION

In this research, the factors affecting the performance of urban road projects and indicators for performance evaluation were investigated using the results of a questionnaire survey. The five most influential factors affecting the performance of road projects were identified as right-of-way acquisition issues, delay to finish, contractor capacity, inflation and scope change with change order, and time performance and quality performance were identified as critical indicators for performance evaluation of urban road projects in Addis Ababa. Minimizing or avoiding the impacts of those influential factors improves the performance of road projects. The survey also revealed low satisfaction in the current project performance and sever impact of waste issues. Lean construction is a project management system which improves the over all performance and value of urban road projects.

Lean Construction tool like IPD allow stakeholders involvement during design and construction phases of road projects in identifying project values, waste issues, tools and techniques and in setting performance indicators and in evaluating project performance. Therefore, implementing lean construction management can improve the performance of urban road projects by minimizing or avoiding the impacts of factors, and waste issues.

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REFERENCES

[1] Abebe Dinku(Dr-ING). Construction Management and Finance. Addis Ababa: AAU Printing Press, 2003.

[2] National Academy of sciences. (2011). Techniques for Effective Highway Construction Projects in Congested Urban Areas, 2011.

[3] UN Habitat. United Nations Human Settlements programme for better urban future. UNNations, 2013.

[4] AACRA, monitoring and evaluation report, 2024

[5] S. Tafesse, "Material waste minimization techniques in building construction projects," Ethiopian Journal of Science and Technology, v, 2021.

[6] Zanjirchi, S. M., & Mehrdad, M. (18 April, 2012). Construction project success analysis from stakeholders' theory perspective. African Journal of Business Management, 2012.

[7] Yibeltal, "A study on sustainable construction waste management practices: the case of building construction projects in Bahir Dar City,Ethiopia," 2020.

[8] A. Tadesse, D. Zakaria, L. Zoubeir, and V. A. Gonzalez, "Characterization of waste in Ethiopian building construction projects," in Proceedings of the 26th annual conference of the International Group for Lean Construction (IGLC), July 2018.

[9] Clifford J. (2003). Construction Management Fundamentals,. McGraw-Hill Science 2003.

[10] O. A. Oguntona, C. O. Aigbavboa, and G. N. Mulongo, An Assessment of Lean Construction Practices in the Construction Industry, Springer International Publishing AG,part of Springer Nature, Berlin, Germany, 2019.

[11] J. G. Sarhan, B. Xia, S. Fawzia, and A. Karim, "Lean construction implementation in the Saudi Arabian construction industry," Construction Economics and Building, 2017

[12] D. D. Viana, C. T. Formoso, B. T. Kalsaas, I. D. Tommelein, and C. L. Pasquire, "Waste in construction: a systematic literature review on empirical studies," in Proceedings of the 20th Annual Conference of the International Group for Lean Construction, San Diego, CA, USA, July 2012.

H. D. Khanh and S. Y. Kim, "Identifying causes for waste factors in high-rise building projects: a survey in Vietnam," KSCE Journal of Civil Engineering, 2014.

[13] J. G. Sarhan, B. Xia, S. Fawzia, and A. Karim, "Lean construction implementation in the Saudi Arabian construction industry," Construction Economics and Building, 2017.

[14] E. N. Shaqour, "Te impact of adopting lean construction in Egypt: level of knowledge, application, and benefits," Ain Shams Engineering Journal, 2022.

[15] M. S. Bajjou and A. Chafi, "Lean construction implementation in the Moroccan construction industry: awareness, benefits and barriers," Journal of Engineering,Design and Technology, 2018.

[16] I. Maradzano, S. Matope, and R. A. Dondofema, "Application of lean principles in the South African construction industry," South African Journal of Industrial Engineering, 2019.

[17] O. O. Fadiya, P. Georgakis, and E. Chinyio, "Quantitative analysis of the sources of construction waste," Journal of Construction Engineering, 2014.

[18] H. D. Khanh and S. Y. Kim, "Identifying causes for waste factors in high-rise building projects: a survey in Vietnam," KSCE Journal of Civil Engineering, 2014.

[19] Project management body of knowledge, PMBOK-6th Edition, 2017