

An Analytical Hierarchy Process of Delay causes in Highway Construction Projects in Iran

Soo-Yong Kim, Kiyanoosh Golchin Rad

Abstract— Recently, the highway construction projects in Iran have been confronted with delay, terminated, or postponed for several years. Although widespread studies have been investigated, regarding to delay issue in developed and developing countries, however, only few studies addressed in Iran. Due to the importance of delay issue and lack of sufficient studies regarding to this topic in Iran, this study aimed to first, discover the most significant causes of delay in highway construction projects, second; prioritize, and rank the critical factors, in order to highlight them for highway construction projects authorities. A verified questionnaire prepared and distributed among the experts in the construction projects of Iran. The valid collected data analyzed by Exploratory Factor Analysis (EFA) to uncover the underlying structure of variables and reduce the number of them. Moreover, Analytical Hierarchy Process (AHP), as one of the prevalent decisions making tools, applied to prioritize and rank the significant factors. The study results revealed that the “Design” and “Contractor” were manifested as the most critical criteria regarding to delay in highway construction projects in Iran. Besides, poor procurement of construction materials, delay in manufacturing materials and accidents during construction were discovered as the most significant factors causing delay. This study contributed first to identify and prioritize the most significant causes of delay in construction projects in Iran, as a developing country, because of lack of sufficient studies regarding to this topic. Additionally it highlights the causes of delay for any involving parties in Iran construction projects in order to eliminate delay.

Keywords—component, formatting, style, styling, insert (*key words*)

I. Introduction

Delay, as one of the most critical issues in construction projects, always has been considered in construction project management and academia as well. Hence, widespread studies have been conducted regarding to this topic. These studies could be generally divided to two perspectives; first, factors causing delay in construction projects; second, delay analysis. Moreover, the delay issue is depended on project type, size, scope and location Elinwa and Joshua (2001). Project delay can be defined by two descriptions; First description defined as “time overrun from the planned or contract schedule”

(Harris & McCaffer, 2013; Majid & McCaffer, 1998; Mendelsohn, 1994; Riad, Arditi, & Mohammadi, 1991; Yates, 1993; Yates & Guhathakurta, 1993); The second described as “the time overrun beyond the date that critical activities have been delayed” (Householder & Rutland, 1990; Rad, 1979; Trauner, 1990).

II. Literature Review

Most of the delay factors in construction projects are common; however, depending on type of projects and scopes, there are different causes. Hence, the widespread studies have been conducted, particularly in developed countries and some studies in developing countries and Middle East as well, regarding to this issue. These studies can be categorized to the factors affecting delay and the delay analysis.

Le-Hoai & Lee applied a comparative study regarding to causes of time-overrun and cost overrun among several selected construction industries in Africa and Asia which achieved to seven factors: Slowness and Lack of constraint; Incompetence; Design; Market and Estimate; Financial capability; Government; and Worker (Le-Hoai, Dai Lee, & Lee, 2008). Kim and Tuan (2016) investigated delay causes in hospital construction in Vietnam. They identified the most important factors as follow;_contractor and owner’s ability, contractor and consultant’s ability, outside effects, designer’s ability, and supervisors’ ability. Park and Kwon (2011) considered influencing factors in infrastructure construction in South Korea. Six critical success factors were recognized namely: competitive contractor, pre-project planning, contract strategy, engineering enforcement, contract guarantee, lessons learned feedback.

III. Data Analysis and Findings

This study attempted to identify, rank, and prioritize delay causes in highway construction projects in Iran. The research methodology has been integrated by Exploratory Factor Analysis (EFA) and Analytical Hierarchy process (AHP).

A. Exploratory Factor Analysis (EFA)

Before analyzing and applying EFA, the Crobach’s Alpha test has been done to determine the internal consistency of items in the survey to measure its reliability. The α is 0.800 which is $0.8 \leq \alpha < 0.9$ and according to Field (2009), the reliability is “good” and it means that the test is 80% reliable. Then, the mean score of each factor computed. According to Majid and McCaffer (1997), the factors with more than 3.5

Soo-Yong Kim, Professor, Department of Civil Engineering
Pukyong National University
Republic of Korea

Kiyanoosh Golchin Rad, PhD Candidate, Department of Civil Engineering
Pukyong National University
Republic of Korea

mean indexes are classified in the “Extremely effective” rating group. Consequently, the factors with less than 3.5 score average mean index removed from the potential factors list. Therefore, the exploratory factor analysis conducted with forty-five factors. EFA conducted using Principal Component’s method with Varimax rotation to see if the observed variables loaded together as expected and meet the criteria of reliability and validity. Therefore, KMO and Bartlett’s test applied to check that factor analysis is applicable or not. The KMO measure was 0.835 which should be higher than 0.6 and Bartlett’s test was less than 0.05 and extremely significant. Therefore, the variables have a correlation and EFA is quite applicable.

B. Analytical Hierarchy Process

The eight components were determined through the EFA, which are namely: Owner, External, Design Government, Contractor, Material, Consultant, and labor. These components were then prioritized through the AHP by weighting their related factors. With respect to the identified factors, AHP procedure has been explained as follow; Initially the AHP goal set as same as the study objective, Prioritize and rank the critical factors causing delay in Highway construction projects in Iran. Hence, an AHP questionnaire based on the hierarchy structure and Saaty’s nine-point scale was designed and distributed among the experts. Out of twenty-five distributed questionnaires, sixteen (four Professors from academia, and twelve experts in highway construction projects with more five years experiences) were replied and made the pairwise comparison. Geo mean index of sixteen responses was calculated by Excel to synthesize the judgments due to obtain a single judgment for the group according to Saaty (2008). The synthesized judgments analyzed by the Expert Choice software to find out the priority weights of each criterion over the criteria with respect to the goal of the study. Consistency Ratios (CR) measured for all criterion and sub-criteria have been checked whether they are less than 10 percentages or not. In this study, all CRs were less than 0.1 (ten percentages) within qualified limits (Table1).

Table1. Priority weights of Criteria and Sub-Criteria

Priorities with respect to:	Priority weights
Level 1: Goal: Delay Causes in Highway Construction Projects	
Level 2:	
CONTRACTOR	0.23
DESIGN	0.148
EXTERNAL	0.137
OWNER	0.126
GOVERNMENT	0.105
MATERIAL	0.103
CONSULTANT	0.095
LABOR PRODUCTIVITY	0.055

Inconsistency = 0.07 with 0 missing judgments.	
Level 3:	
>OWNER	
Poor communication and coordination consultant and contractor	0.286
Lack of incentives for contractor to finish ahead of schedule	0.193
Delay in progress payments (Funding problems)	0.159
Delay in approving design documents	0.136
Change orders	0.125
Long period between design and time of bidding/tendering	0.1
Inconsistency = 0.05 with 0 missing judgments.	
>EXTERNAL	
Global financial crisis	0.291
Misunderstanding of owner’s requirements by	0.22
Different tactics patterns for bribes	0.22
Inappropriate construction methods	0.146
Frequent equipment breakdowns	0.124
Inconsistency = 0.03 with 0 missing judgments.	
>DESIGN	
Poor use of advanced engineering design software	0.338
Complexity of project design	0.288
Shortage of Equipment	0.205
Defective design made by designers	0.169
Inconsistency = 0.02 with 0 missing judgments.	
>GOVERNMENT	
Unexpected surface& subsurface conditions	0.338
Inappropriate government policies	0.288
Thefts done on site	0.205
Inadequate production of raw material in the country	0.169
Inconsistency = 0.02 with 0 missing judgments.	
>CONTRACTOR	
Ineffective project planning and scheduling	0.333
Inappropriate contractor’s policies	0.333
Inadequate contractor experience	0.333
Inconsistency = 0 with 0 missing judgments.	
>MATERIAL	
Delay in manufacturing materials	0.413
Shortage of construction materials	0.327
Damage of sorted materials	0.26

Inconsistency = 0.05 with 0 missing judgments.	
>CONSULTANT	
Accidents during construction	0.338
Delay in approving major changes in scope of work	0.288
Lack of consultant experience in construction projects	0.205
Price fluctuations	0.169
Inconsistency = 0.02 with 0 missing judgments.	
>LABOR PRODUCTIVITY	
Poor procurement of construction materials	0.667
Low productivity of labor	0.333
Inconsistency = 0 with 0 missing judgments.	

iv. Conclusion

This study attempted; to investigate the factors affecting delay in highway construction projects in Iran; and it contributed to prioritize and rank critical factors, in order to highlight them for Iranian construction projects authorities. To this aim, an intensive literature review performed to identify the potential factors. The designated questionnaire modified through the pilot study and distributed to the experts in construction projects in Iran. The valid selected data analyzed by EFA and AHP tools. Eventually, from the study results, it revealed that the “Design” and “Contractor” were the most prioritized criteria. Moreover, “poor procurement of construction materials”, “delay in manufacturing materials” and “accidents during construction” were the most significant sub-criteria. Therefore, contractors and designers are highly recommended to consider these factors in order to eliminate delay and achieve the project success. The study results would be applicable in highway construction projects in Iran, and other Middle Eastern projects, based on the similarity of construction projects of that area.

Acknowledgment

This study was supported by a Research Grant of Pukyong National University (2017 year).

References

Elinwa, A. U., & Joshua, M. (2001). Time-overrun factors in Nigerian construction industry. *Journal of Construction Engineering and Management*, 127(5), 419-425. doi: [http://dx.doi.org/10.1061/\(ASCE\)0733-9364\(2001\)127:5\(419\)](http://dx.doi.org/10.1061/(ASCE)0733-9364(2001)127:5(419))

Field, A. (2009). *Discovering statistics using SPSS*: Sage publications.

Harris, F., & McCaffer, R. (2013). *Modern construction management*: John Wiley & Sons.

Householder, J. L., & Rutland, H. E. (1990). Who owns float? *Journal of Construction Engineering and Management*, 116(1), 130-133. doi: [http://dx.doi.org/10.1061/\(ASCE\)0733-9364\(1990\)116:1\(130\)](http://dx.doi.org/10.1061/(ASCE)0733-9364(1990)116:1(130))

Kim, S.-Y., & Tuan, K. N. (2016). Delay factor analysis for hospital projects in Vietnam. *KSCE journal of civil engineering*, 20(2), 519-529. doi: <http://dx.doi.org/10.1007/s12205-014-0679-8>

Le-Hoai, L., Dai Lee, Y., & Lee, J. Y. (2008). Delay and cost overruns in Vietnam large construction projects: A comparison with other selected countries. *KSCE journal of civil engineering*, 12(6), 367-377. doi: <http://dx.doi.org/10.1007/s12205-008-0367-7>

Majid, M. A., & McCaffer, R. (1997). Assessment of work performance of maintenance contractors in Saudi Arabia. *Journal of management in engineering*, 13(5), 91-91. doi: [http://dx.doi.org/10.1061/\(ASCE\)0742-597X\(1997\)13:5\(91\)](http://dx.doi.org/10.1061/(ASCE)0742-597X(1997)13:5(91))

Majid, M. A., & McCaffer, R. (1998). Factors of non-excusable delays that influence contractors' performance. *Journal of management in engineering*, 14(3), 42-49. doi: [http://dx.doi.org/10.1061/\(ASCE\)0742-597X\(1998\)14:3\(42\)](http://dx.doi.org/10.1061/(ASCE)0742-597X(1998)14:3(42))

Mendelsohn, R. (1994). Early-completion schedules: the promise and pitfalls. *Journal of management in engineering*, 10(1), 28-30. doi: [http://dx.doi.org/10.1061/\(ASCE\)9742-597X\(1994\)10:1\(28\)](http://dx.doi.org/10.1061/(ASCE)9742-597X(1994)10:1(28))

Park, H.-S., & Kwon, S. (2011). Factor analysis of construction practices for infrastructure projects in Korea. *KSCE journal of civil engineering*, 15(3), 439-445. doi: <http://dx.doi.org/10.1007/s12205-011-1064-5>

Rad, P. F. (1979). Delays in construction of nuclear power plants. *Journal of the Energy Division*, 105(1), 33-46.

Riad, N., Arditi, D., & Mohammadi, J. (1991). A conceptual model for claim management in construction: An AI approach. *Computers & Structures*, 40(1), 67-74. doi: [http://dx.doi.org/10.1016/0045-7949\(91\)90458-X](http://dx.doi.org/10.1016/0045-7949(91)90458-X)

Saaty, T. L. (2008). Decision making with the analytic hierarchy process. *International journal of services sciences*, 1(1), 83-98. doi: <https://doi.org/10.1504/IJSSCI.2008.017590>

Trauner, T. J. (1990). *Construction delays: Documenting causes, winning claims, recovering costs*: RS Means Company.

Yates, J. (1993). Construction decision support system for delay analysis. *Journal of Construction Engineering and Management*, 119(2), 226-244. doi: [http://dx.doi.org/10.1061/\(ASCE\)0733-9364\(1993\)119:2\(226\)](http://dx.doi.org/10.1061/(ASCE)0733-9364(1993)119:2(226))

Yates, J., & Guhathakurta, S. (1993). International labor productivity. *COST ENGINEERING-ANN ARBOR THEN MORGANTOWN-*, 35, 15-15.



Prof. Soo Yong Kim is a full professor at the Department of Civil Engineering at Pukyong National University. He holds the PhD of Industrial Engineering from KAIST. He is the advisor of Construction Engineering and Management Lab. His major interests are Public Private Partnership (PPP) and Value Engineering (VE).



Kiyanoosh Golchin Rad is a PhD candidate of Construction Engineering and Management at Pukyong National University. He holds a B.sc in Civil Engineering and M.sc in Construction Management from University Technology of Malaysia (UTM). His current research interest is construction labor productivity.