

Anatomization of Cost and Time Control Factors in Construction



Helis Joseph Prem F, Mahalakshmi Mathivanan

Abstract: *The Cost escalation and Time overrun has become the common problem in various construction projects across the world which are forcing the construction firms to compromise with the quality and completion time of the building. This can possibly be reduced by concentrating on the key sectors during building construction that are most probable to cause adverse effects on the project objectives. These key sectors that spoils the objectives of projects can be found with the help of a descriptive survey drafted using the significant factors gathered from various Literatures. As a result of survey 38 factors in 7 major groups such as Owner, Consultant, Contractor, Material, Equipments, Labour, External related causes were formulated and the factors were to be assessed based on the Response Scale. These Questionnaire were then circulated among various construction parties such as Owner, Consultant, Contractor in Tamil Nadu. About 191 replies were received in which 66% of them were related Contractors, 21% were Consultants, and 13% were Owner related. The study was carried out by finding the Relative Importance Index of each factor and it was found that the influencing factors were Inadequate Fund for Project, Material Cost Inflation, Changes in Government Regulations, Unrealistic Contract Duration and Requirements imposed by Owner, Inadequate Resources for Construction. Based on the Group Importance Index the Owner group was ranked the highest which signifies that it needs to be concentrated more to reduce the adverse effects.*

Keywords: *Cost and Time Overrun, Construction, Tamil Nadu*

I. INTRODUCTION

The Construction Sector is a vital source that occupies an important role in developing the national economy of various countries. The construction industry has a large impact on the rate of GDP as it provides a large scope of employment for a vast amount of individuals around the world, and it is said that the construction activities have become a significant market indicator as the industry produces a variety of products and consumes more resources than any other industries. For these construction projects to be successful it should not only meet quality output standards but also time and budget objectives. Therefore, exploring the causes are the only ways of keeping the cost within budget and timely execution. Kumaraswamy [12] stated that a project is successful only if it is completed on time within budget and anticipated quality standard. In recent observation Indian Projects ends up with extra time, money and Resource .

Manuscript published on November 30, 2019.

* Correspondence Author

Helis Joseph Prem F*, Student, SOCE, SASTRA Deemed to be University, Thanjavur, 613401, India

Mahalakshmi Mathivanan*, Faculty, SOCE, SASTRA Deemed to be University, Thanjavur, 613401, India

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an [open access](http://creativecommons.org/licenses/by-nc-nd/4.0/) article under the CC-BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

Delay in completion stimulates the cost of construction, because of immense capital funds held up, ends in reduced income. It is of immense importance to determine the constraints by way of analysis and evaluation and suggest the best mitigation measures. During the phase of construction it is the duty of the project managers to streamline the project to avoid the escalation of both cost and time.

The Main objectives of this research study are:

1. To determine the significant factor and factor category causing cost and time overrun in the construction projects in Tamil Nadu by evaluating their Relative Importance.
2. To find the causes of each significant factor from the perspective of the major participants of the industry – Owner, Consultant, Contractor.
3. To evaluate the reliability of the data collected
4. To rank the groups based on their group importance Index

II. METHODOLOGY

A. Literature Survey

The Literatures pertaining to the study of factors causing delay/time overrun, cost overrun were collected and studied to identify the most significant factors, its causes and mitigation measures that were suggested by the researchers. Murali Sambasivan and Yau Wen Soon [1] led a study in Malaysia to pinpoint the factors causing delay and its effect on completion of projects in the Malaysian Industry by adopting an integrated approach to find the effect of certain causes on specific effects. The authors carried out a survey comprising of 28 different delay factors and 6 effects of these on about 150 respondents. The result of the survey concluded the 10 most eloquent factors of setback that were improper planning, improper site supervision, lack of experience of contractor, inadequate finance by owner and payment delay for work, misunderstanding with subcontractors, material shortage, meager labor source, lack of availability of equipment and its failure, communication lag between parties, and errors in construction stage. The 6 main effects of delay were: Delay, cost overrun, litigation, ,Discord ,total dereliction and arbitration. The authors also suggested certain prescriptions to dwindle the setback in completion of the Construction job.

Peter F. Kaming, et al [2] carried out a survey among the Project managers in sky-scrapping in Jakarta and Yogyakarta to determine the influence and frequency of the sources of escalation. The Author determined that Escalation in material cost; inaccuracy of estimation of materials and project entanglement are the main causes.

Anatomization of Cost and Time Control Factors In Construction

The predominant causes were changes in design, less labour productivity and improper planning.

Ayman H. Al-Momani [3] carried out an investigation to determine the delay factors on 130 construction work in Jordan to establish sufficient evaluation prior to Contract using Quantitative data analysis to aid the construction managers in Jordan. The author concluded from the survey that the most influencing factors indicated in the survey of 130 public projects were carelessness of the owner, weather change in work orders, site location, delay in delivery, economy, faulty design and increase in requirement of materials are the main causes of delay. From the findings the author believes the study will furnish a proper direction regarding organizational dilemma and some protocol for them to carry out their projects P. A. Koushki et al, [4] employed an audit to determine the setback and increase in the expenditure correlated with the housing projects by the Private Companies in Kuwait. The author conducted a survey of 450 owners and developers of residential project in 27 selected districts in Kuwait for the study. The demographic analysis of the owners and developers, the working phases of the projects the pre-construction planning, the design, were determined by the author. The author found the three adverse causes of delays as changes in command, owner's economic status and inadequate knowledge for the owner regarding the construction and with respect to the cost overrun the 3 main sources for setback were found as contractor based, material based problems and, owner's financial constraints. The author proposed recommendations for lowering project time and escalation of cost in projects were the scarcity in funds, allocation of schedule of duration and capital at the design phase, and election of an experienced consultant and a trustable contractor to execute the work. K.C. Iyer, K.N. Jha [5] carried out a survey on the causes affecting cost efficiency of the Indian projects, in which the author produced the 55 governing and affecting attributes through research and seven factors were extracted from personal interview. The author concluded that the important factors obtained by the analyses are: project director's efficiency; support of higher official; director's coordination and commanding skill; participants response; communication among project participants; and owner's potential and favoring weather condition. The negative cost performance affecting factors were dispute among project participants; unawareness and lack of experience; slow decision making, meager project aspect and; unfriendly working and weather condition; truculent contention during tender and inadequate bidding time. As the result of survey the author produced that communication amidst project individuals as the most important of all with utmost positive impact on project cost. Long Le-Hoai et al, [6] drafted a survey through questionnaire to figure out the significant factor of delays and cost escalation in Vietnam by questioning eighty seven professional belonging to construction. The study drafted twenty one delay sources and escalation in budget of project with Residential, industrial project and ranked them with respect to various indices such as frequency, severity and importance indices. The author found that there were no discrepancies between the three principal parties viewpoints in the project. The author also made a comparison of the

sources of delay and cost escalation in various construction industries in and around Asian, African countries. The author adopted factor analysis technique to segregate the sources of delay, which gave up 7 factors: late completion and Lack of monitorization; Incapability; Poor Design; Market and Estimate; Financial ability; Government; and Work force. M. E. Abd El-Razek et al, [7] aimed to determine the main source of escalation of project time in buildings situated in Egypt from the perceptiveness of Owner, Consultant, and Contractor. The author compiled a list of delay that was appropriated to Egypt by means of Literature review in seven semi-structured interviews. The author conducted a survey by means of questionnaire that compiled list of delays and to detect the most viable factors of setback. Through the survey: Contractors Financial strength, delays in payment by owner to contractor, changes in design, insufficient fund allocation during construction, and improper exercise of construction management are major factors. Author determined that the contractor and the owner were having an opposing view on each other, and the consultant was having an intermediate view. The author concluded with an advice to significantly decrease delay by a combined effort based on teamwork is necessary.

Kamrul Ahsan, Indra Gunawan [8] focused on studying the budget and delay concerning International Development (ID) projects through critical analysis. The authors analyzed the 100 Asian Development Bank sponsored projects organized by various countries to identify the most delayed projects that undergoes cost underrun and duration changes in projects. The result of examination showed that utmost projects experienced delay in timetable and cost underrun. Authors determined the major causes to be prolonged contract time, Attainment, public works and procurement of project site, and selection of consultant. Whereas the critical causes of delay were natural disaster and host country administration. According to the author the main sources of cost underrun are weakening of local cash roll; antagonistic bidding price lesser than the anticipated bid, and large contingency budgets.

Yakubu Adisa Olawale and Ming Sun [9] organized a questionnaire on 250 building projects in United Kingdom following that they conducted direct interviews with experienced engineers of various organizations from which they identified the construction projects that affects both time, cost control factors. The authors also developed 90 mitigation measures for the significant 5 leading factors such as changes in design, risks, unreliable evaluation of project time, ramification and subcontractors incompetency. The authors suggest that these could be used as checklist during construction by Project Head to improve the objectives of their projects

Frank D.K. et al, [10] did a survey to find the sources of delay in Ghana based on the viewpoint of the key project parties - Owner, consultants, and contractors. The authors identified 32 delay factors through literatures and by conducting examination of 15 major members belonging to construction work. They also categorized the delay causes into 9 major groups to conduct a questionnaire survey.

The authors found the causes and the groups and ranked them incorporating relative method. They found from the results that due to the financial group factors that placed top amidst the top factors causing setback in construction works. Factors of the budgeting group were processing payment deeds, problems due to fluctuation in prices, the second are materials factor lined up with scheduling and controlling factors. Hemanta Doloi et al, [11] anticipated to find the reasons of time escalation in Indian Projects and to develop a clear understanding about the impact of delay among the industrial professionals. The authors adopted questionnaire survey and personal interviews as the basis of the research. The authors determine the factors of escalation of time in construction field in India and then formed the correlation between the severe attributes to induce a prototype for predicting and assessing the effect of these factors and significance of these were analyzed using factor analysis and regression models. The authors found the most crucial factors of project delay from the factor analysis to be lack of responsibility; poor site administration; lack of trust between project parties ; unsuitable execution and drafting; inadequacy in understanding the objective; poor delivery of information; and amateur contract. The most important reasons as the result of analysis are found to be Late decision making by owner, less productivity of workers , noncooperation for changes and reconstruction due to mistakes by architects in construction.

Daniel W. M. et. al, [12] determined the important aspects of time overrun in the Hong Kong in building construction industry. Authors framed a descriptive survey with eighty three delay factors categorized into 8 major groups. The result of the study was analyzed from the responses of 78 construction personnel to evaluate the importance indices of each factor. The study determined that similar viewpoints between owners and consultants were found and there was a significantly no similarity in judgment between consultants and contractors, as well as between owners and contractors, with respect to the rankings of the individual causes and its

categories. The authors provided suggestions for improving the efficiency of management of project based on the results and the author believes that this study could be a foundation for future research to develop construction time prediction models for the projects.

B. Questionnaire Drafting

These literatures are then collectively analyzed to determine the significant factors causing project delay and cost escalation occurring repeatedly in various construction projects around the world. These literatures also provided guidance in employing the system of reasoning for the received responses, and various tests to determine the reliability of the data. A Pilot survey was done with the help of experienced person in the construction field to determine the level of clarity of the questionnaire that has to be distributed to the construction parties. The next stage involved drafting of the questionnaire survey that comprises of 38 factors classified based on seven major groups such as owner, contractor, consultant, material, labour, equipment, external causes etc. The Questionnaire consists of two segment in which the first segment was to find the details pertaining to the respondents such as type of organization of the respondent, their designation at the organization, experience in the field, project type they are educated , whereas the second segment consists of the factors which are assessed by the respondents with the use of Response Scale that demonstrates 1 which denotes Strongly disagree to 5 denoting Strongly agree. The Questionnaire survey was distributed to respondents experienced in the construction industries in Tamil Nadu. The use of Relative Importance Index to determine the most significant factor, Cronbach Alpha test for internal data reliability, Spearman Rank Correlation for determining the agreement between the major groups was adopted. The table below shows the selected significant factors in its respective groups.

Table1: Factors considered for the Questionnaire Survey

S.No	Group	ID	Factors
1	Owner	1.1	Delay in payment to Contractor by Owner
		1.2	Delay in decision making by Owner
		1.3	Improper Communication and Coordination
		1.4	Owner interference
		1.5	Inadequate Fund for Project
		1.6	Unrealistic Contract Duration and Requirements imposed by Owner
2	Consultant	2.1	Inadequate experience of Consultant
		2.2	Late Inspection and Testing by Consultant
		2.3	Delay in Approving Design Documents
		2.4	Inadequate details in drawings
		2.5	Improper Estimation and Planning
		2.6	Poor Design by Consultant



Anatomization of Cost and Time Control Factors In Construction

3	Contractor	3.1	Poor Site Management and Supervision
		3.2	Improper Planning and Scheduling of Project
		3.3	Rework during construction
		3.4	Subcontractor Incompetency
		3.5	Conflicts between Contractor and Other Parties
		3.6	Improper Execution of Work
		3.7	Pressure due to Demand and Supply Gap on Contractor
4	Material	4.1	Inadequate Resources for Construction (eg. Natural Sand)
		4.2	Alteration in Material Types and Specification
		4.3	Delay in Procurement of Materials
		4.4	Material Cost Inflation
		4.5	Inefficient Storage of Materials
5	Labour	5.1	Poor Labour Productivity
		5.2	Shortage of Skilled Labour
		5.3	Labour Disputes
		5.4	Labour Cost Inflation
6	Equipment	6.1	Shortage of Equipment
		6.2	Low Productivity and Efficiency of Equipment
		6.3	Low level of Operator's Skill
		6.4	Equipment Breakdowns
		6.5	Lack of High-Technology Equipment
7	External	7.1	Effect of Weather
		7.2	Changes in Government Regulations
		7.3	Delay in Approval by Environmental Clearance and Municipality
		7.4	Accidents and Unforeseen Ground Conditions during Construction
		7.5	Natural Disasters

III. RESULTS AND DISCUSSION

A. Demographic Analysis of Respondents

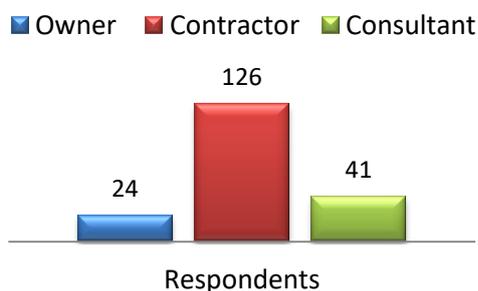


Fig 1 : Nature of Respondents

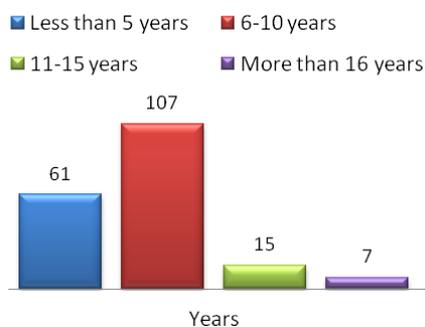


Fig 2 : Working Experience of the Respondents

The Questionnaire survey circulated produced results from about 191 respondents, in which 126 respondents were related to contractors, 41 were consultant and 24 were owners of them 107 respondents had an experience of 6-10 years, 61 had less than 5 years, 15 had 11-15 years and 7 of them had more than 16 years of experience

■ Directors / Proprietor
■ Project Manager
■ Engineer

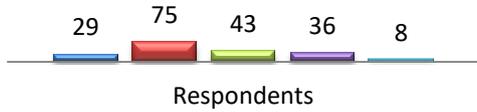


Fig 3 : Designation of Respondents

■ Residential Buildings
■ Infrastructural Buildings
■ Commercial Buildings
■ Industrial Buildings

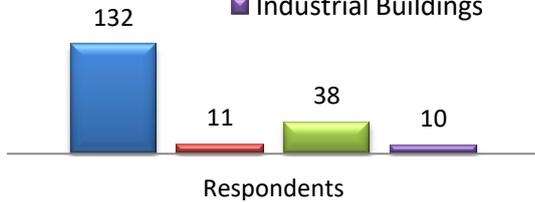


Fig 4 : Type of work executed by respondents

The Survey conducted comprised of 29 Directors, 75 Project Managers, 43 Engineers, 36 Supervisors, and 8 Architects of them 130 were indulged in Residential Projects, 11 in

Infrastructural Projects, 38 in Commercial Projects, 10 in industrial Projects.

B. Data Analysis

The research was done using SPSS software where the collected data of 191 forms filled by the respondents were entered into the sheets for further analysis to gather insights. The effect of each factor causing time and cost overrun was examined and ranking of these factors are done with the implementation of the formulae of Relative Importance Index (RII) which is calculated using the below formula,

$$RII = \frac{\sum w}{A * N} \quad (0 \leq RII \leq 1)$$

Where,
 W – value ranging from 1 - 5;
 A – is the maximum or utmost value and;
 N – is the total number of feedback.

Table 2: Top ten factors based on Owners perspective

No	Factors	Owner		Group
		RII	RANK	
1	Material Cost Inflation	0.742	1	Material
2	Pressure due to Demand and Supply Gap on Contractor	0.733	2	Contractor
3	Changes in Government Regulations (e.g. GST)	0.683	3	External
4	Improper Estimation and Planning	0.675	4	Consultant
5	Inadequate Resources for Construction (eg. Natural Sand)	0.658	5	Material
6	Delay in Approving Design Documents	0.650	6	Consultant
7	Poor Design by Consultant	0.642	7	Consultant
8	Equipment Breakdowns	0.600	8	Equipment
9	Delay in payment to Contractor by Owner	0.583	9	Owner
10	Improper Planning and Scheduling of Project	0.583	10	Contractor

Table 3: Top ten factors based on Consultant perspective

No	Factors	Consultant		Group
		RII	RANK	
1	Inadequate Fund for Project	0.810	1	Owner
2	Pressure due to Demand and Supply Gap on Contractor	0.776	2	Contractor
3	Inadequate Resources for Construction (e.g. Natural Sand)	0.722	3	Material



Anatomization of Cost and Time Control Factors In Construction

4	Changes in Government Regulations (e.g, GST)	0.717	4	External
5	Material Cost Inflation	0.707	5	Material
6	Improper Planning and Scheduling of Project	0.693	6	Contractor
7	Owner interference	0.683	7	Owner
8	Improper Execution of Work	0.683	8	Contractor
9	Delay in decision making by Owner	0.678	9	Owner
10	Unrealistic Contract Duration and Requirements imposed by Owner	0.659	10	Owner

Table 4: Top ten factors based on Contractor perspective

No	Factors of Cost and Time Overrun	Contractor		Group
		RII	RANK	
1	Inadequate Fund for Project	0.711	1	Owner
2	Unrealistic Contract Duration and Requirements imposed by Owner	0.702	2	Owner
3	Delay in payment to Contractor by Owner	0.689	3	Owner
4	Material Cost Inflation	0.679	4	Material
5	Changes in Government Regulations (e.g, GST)	0.670	5	External
6	Accidents and Unforeseen Ground Conditions during Construction	0.662	6	External
7	Inadequate Resources for Construction (e.g. Natural Sand)	0.657	7	Material
8	Effect of Weather (Hot, Rain, Snow etc)	0.632	8	External
9	Delay in decision making by Owner	0.632	8	Owner
10	Improper Communication and Coordination	0.629	10	Owner

Table 5: Top ten factors based on overall perspective

No	Factors	Overall		Group
		RII	RANK	
1	Inadequate Fund for Project	0.697	1	Owner
2	Material Cost Inflation	0.693	2	Material
3	Changes in Government Regulations (e.g, GST)	0.682	3	External
4	Unrealistic Contract Duration and Requirements imposed by Owner	0.675	4	Owner
5	Inadequate Resources for Construction (e.g. Natural Sand)	0.671	5	Material
6	Delay in payment to Contractor by Owner	0.667	6	Owner
7	Pressure due to Demand and Supply Gap on Contractor	0.658	7	Contractor
8	Owner interference	0.627	8	Owner
9	Accidents and Unforeseen Ground Conditions during Construction	0.623	9	External
10	Effect of Weather (Hot, Rain, Snow etc)	0.620	10	External

Table 6: Group Importance Index

No	ID	Group	Group Importance Index	RANK
1	1	Owner	0.6522	1
2	4	Material	0.5853	2
3	7	External	0.5621	3
4	3	Contractor	0.5575	4
5	2	Consultant	0.5531	5
6	5	Labour	0.5325	6
7	6	Equipment	0.4477	7

C. Reliability Analysis

The authenticity of the collected response is analyzed in which it was found that Cronbach alpha(α) should be in the range 0 to 1, and for α greater than 0.9, the data is said to be of excellent consistency and reliability. If the value is between 0.8 to 0.9 it is said to be good. The Cronbach alpha is found using the formula,

$$\alpha = \frac{k}{k - 1} \left(1 - \frac{\sum \sigma_i^2}{\sigma^2} \right)$$

where

$\sum \sigma_i^2$ = Variance that was found from the observed test factors;

k=Total number of variables that are considered in the research;

σ_i^2 =Variance in scales on each factor.

The Spearman's rank correlation is used to determine the possibility of agreement between the major groups mentioned in the study. The Value ranges from -1 to +1 which implies no agreement between groups to perfect agreement between the groups. The spearman's rank correlation is done using the formula

$$r_s = 1 - \frac{6 \sum d^2}{N^3 - N}$$

Where

r_s =Spearman's rank correlation coefficient between the associated parties,

d= total difference obtained from the rank which was awarded for each cause,

N=Total number of delay factors **Table 7 : Cronbach Alpha Results**

Cronbach Alpha	
Group	A
Owner	0.9204
Contractor	0.9102
Consultant	0.8825
Equipment	0.8825
Labour	0.8688
Material	0.8103
External	0.6289
Total	0.9607

Table 8 : Spearman Rank Correlation Results

Spearman Rank Correlation	
Correlation between	r_s
Owner vs Contractor	0.3899
Owner vs Consultant	0.3369
Consultant vs Contractor	0.4879

The results from the Cronbach α tests showed that the values have good consistency and reliability with a total value of 0.9607. The results of rank correlation showed that the correlation coefficient value was 0.4879 between consultant and contractor, the value was 0.3899 in case of owner and contractor whereas it was 0.3369 between owner

and consultant. From the above results it was determined that disagreements of the owner between other two groups were high which signifies the lack of understanding between them.

IV. CONCLUSION

The main goal of the study was determining the significant factors and groups that are most vulnerable to cause cost escalation and delay in project construction. To fulfill the objective of the study a questionnaire was drafted after analyzing the factors using various literatures and it was then circulated among skillful personnel in the field. As the result of the survey about 191 responses were gathered from respondents from Tamil Nadu to produce the major finding as;

- 1) It was found that the most important factors from the view of the Owner was material cost inflation, from the view of the Consultant the material cost inflation, and from the perspective of Contractor Inadequate Fund for Project
- 2) The Overall significant factors were Inadequate Fund for Project, Material Cost Inflation, Changes in Government Regulations, Unrealistic Contract Duration and Requirements imposed by Owner, Inadequate Resources for Construction.
- 3) It was found from direct interviews with experienced persons in the field, that main reason for the delay and price escalation was due to factors like material cost inflation, inadequate resources for construction , change in government regulations. It was found that due to environment issues the use of Natural sand has been restricted which has caused delay in construction whereas the use of M-sand as a substitute is not being favored by the buyers in case of flats. The implementation of GST has also affected the pricing of the materials for construction as most of the materials falls within the GST rate above 18 % so the rate of materials has increased that causes owners to make more fund for the construction to carry out.
- 4) The major fault with these construction projects is that the estimation of project time and project cost is not carried out properly and also the estimation after the completion of the projects should be made to determine differences in actual project duration and its budget. It also provides information regarding the factors that causes increase in cost and that delays the project time

REFERENCES

1. M. Sambasivan and Y. Soon, "Causes and effects of delays in Malaysian construction industry", International Journal of Project Management, vol. 25, no. 5, pp. 517-526, 2007.
2. P. F. Kaming, P. O. Olomolaiye, G. D. Holt, and F. C. Harris, "Factors influencing construction time and cost overruns on high-rise projects in Indonesia," Construction Management and Economics, vol. 15, no. 1, pp. 83-94, 1997.
3. A. H. Al-Momani, "Construction delay: a quantitative analysis," International Journal of Project Management, vol. 18, no. 1, pp. 51-59, 2000.
4. P. A. Koushki, K. Al-Rashid, and N. Kartam, "Delays and cost increases in the construction of

- private residential projects in Kuwait,” *Construction Management and Economics*, vol. 23, no. 3, pp. 285–294, 2005.
5. K. Iyer and K. Jha, “Factors affecting cost performance: evidence from Indian construction projects,” *International Journal of Project Management*, vol. 23, no. 4, pp. 283–295, 2005.
 6. L. Le-Hoai, Y. D. Lee, and J. Y. Lee, “Delay and cost overruns in Vietnam large construction projects: A comparison with other selected countries,” *KSCE Journal of Civil Engineering*, vol. 12, no. 6, pp. 367–377, 2008.
 7. M. E. A. El-Razek, H. A. Bassioni, and A. M. Mobarak, “Causes of Delay in Building Construction Projects in Egypt,” *Journal of Construction Engineering and Management*, vol. 134, no. 11, pp. 831–841, 2008.
 8. K. Ahsan and I. Gunawan, “Analysis of cost and schedule performance of international development projects,” *International Journal of Project Management*, vol. 28, no. 1, pp. 68–78, 2010.
 9. Y. A. Olawale and M. Sun, “Cost and time control of construction projects: inhibiting factors and mitigating measures in practice,” *Construction Management and Economics*, vol. 28, no. 5, pp. 509–526, 2010.
 10. H. Doloi, A. Sawhney, K. Iyer, and S. Rentala, “Analysing factors affecting delays in Indian construction projects,” *International Journal of Project Management*, vol. 30, no. 4, pp. 479–489, 2012.
 11. F. D. Fugar and A. B. Agyakwah-Baah, “Delays in Building Construction Projects in Ghana,” *Construction Economics and Building*, vol. 10, no. 1-2, pp. 103–116, 1970.
 12. D. W. Chan and M. M. Kumaraswamy, “An evaluation of construction time performance in the building industry,” *Building and Environment*, vol. 31, no. 6, pp. 569–578, 1996.

AUTHORS PROFILE



Helis Joseph Prem F, Post graduate Student, School of Civil Engineering, SASTRA Deemed to be University, Thanjavur, Tamilnadu, India.



Mahalakshmi Mathivanan, Assistant Professor, School of Civil Engineering, SASTRA Deemed To Be University, Thanjavur, Tamilnadu, India.
Email: mahalakshmi@civil.sastra.edu