Research Paper **Open Access**

Saurav Dixit*

Study of factors affecting the performance of construction projects in AEC industry

DOI 10.2478/otmcj-2020-0022
Received: December 24, 2019; accepted: May 08, 2020

Abstract: A construction project is like a living entity and requires the interconnection and coordination of several stakeholders and many of them have their objectives, which sometimes create a conflict of interest between the teams and within the teams. The success of any project is repeatable, and a set of attributes for the success of a construction project can be identified, requiring discipline and hard work. The construction sector is the engine of growth for a nation and supplies services and goods to other industries. The objective of the study is to analyse the enabling factors affecting the performance construction projects in Architecture Engineering and Construction industry. The methodology chosen for the study is to collect primary data from the Indian construction industry using structured questionnaire surveys. The collected data are analysed using reliability and factor analyses. The findings of the study provide the value of reliability, that is, Cronbach's alpha value of (0.86) of the data collected using a questionnaire survey. Furthermore, exploratory factor analysis produced five main significant factors based on covariance between the attributes and grouped into factors such as site management and coordination, leadership and financial management, planning, commitment, and coordination having a variance of 17.65, 11.8, 9.1, 8.5, and 7.5%, respectively. This article is the extended version of the paper accepted and presented at CCC2019.

Keywords: project performance, construction project, construction management, construction productivity, project management, building construction

1 Introduction

Construction industry in India is unorganised and mostly dominated by people who are uneducated and ignorant of sustainable practices and are driven only by commercial viability, without considering other factors, such as quality, sustainability, health & safety and operability (Al-Tabtabai et al. 1997; OECD 2012; Sapuay 2016). First, the lack of awareness and insensitivity to sustainable development is a major problem in the sector and second the initial investment needed for green construction is high compared to conventional construction (Kirmani 1988). The question doesn't stop here. India is still seeing a large number of illegal construction activities where the developers can get away from penalties, ignoring the rules that will lead to a poor outcome (Pheng et al. 2016; Dallasega and Rauch 2017; Singh et al. 2018). Each construction project is unique and complex and begins with unique parameters and massive investment with good effort and planning (Abdul Kadir et al. 2005). But as planned, only a few projects succeed. The construction sector is considered to be the engine of growth for a country's economy, providing links and job opportunities to other industries. On average, the contribution of the construction sector to the global economy has been around 7–10% over the last 5 years (Dixit et al. 2017). However, the contribution of the construction sector to Indian GDP has been around 8–9% over the last 5 years. The Indian Construction Industry is very complex, fractured, and largely unorganised. The professional and productive labour force has always been one of the most critical issues for the industry (Kirmani 1988; Guntuk and Koehn 2010; McKinsey and Company 2010; Mani et al. 2017; Dixit and Saurabh, 2019). Due to the unique nature of the work, planning, timely delivery and reliability have always been a subject to concern.

1.1 Project performance

Construction industry is one of the main contributors to the development of any country, which is the most important in creating jobs when it comes to India. However,

***Corresponding author: Saurav Dixit,** Editorial Board Member at Construction of Unique Buildings and Structures, St. Petersburg, Russia, Sector 106, Faridabad, Haryana 121101, India.
E-mail: sauravarambol@gmail.com

most of the times, it has seen the downturn because of many internal and external reasons. Nevertheless, the most important of them is time delay and cost overrun that hampers the performance of the construction project. The performance of construction could be assessed by the completion schedule, cost of completion, productivity of works completed, and safety (Molavi and Barral 2016). This is the most important reason why many of the projects are left incomplete and developers move on to the next project. This is very important to understand the effect and factors affecting the time delay and cost overrun.

2 Literature review

A project can be defined as a temporary endeavour, with a definite timeline to follow. To be able to complete its intended purpose or scope, it uses resources such as man, materials, plants and equipment. One thing we should keep in mind as a constructional professional is that no matter how best we plan our course of action, there will be some lapses and we all know about Parkinson's Law is if anything that might wrong in a project is eventually planned accordingly. For a project to be successful, a project must be completed within the requirement and limits of scope, quality, and time and cost (Ogunbiyi et al. 2014; Parida and Ray 2015). Lee et al. (2007) conducted a case study of three infra-projects under construction. This study suggests optimising the rapid-track construction approach plan by using pre-cast assembly units for three restoration projects and assessing the impact on the productivity of the operation. The study provides an understanding and deeper knowledge of the productivity of five major retrofit/rework activities (i.e., basement, AC pavement, roadway excavation, concrete slab demolition and concrete pavement) implemented in three experimental long-term pavement rehabilitation projects in California. Improvements in performance and learning curve have been seen in the case of the full renovation of work compared to partial renovation work. The study suggests that variance/contingency should be considered in the preparation of recovery and rehabilitation work schedules.

2.1 Issues and challenges in the construction industry

2.1.1 Labour shortages and variability in prices

One of the most important problems is the ongoing shortage of jobs in the construction industry. At the end of 2018, there are almost 290,000 open jobs in the construction sector and it is extremely difficult to find skilled workers. Because of the low unemployment rate, businesses will retain applicants who already have work. Furthermore, as a result of increased raw material costs, the contractors are at risk of cost changes caused by fixed price agreements and costly home construction. Small construction companies have less versatility as prices change rapidly and are significantly affected by changes in rates between the start and the end of the design (Table 1).

Tab. 1: Attributes identified from the literature affecting the performance of construction projects

S. No	Reference source	Attributes identified
1	Apolot et al. (2011)	Willingness to adopt change, interpersonal skills, skilled labour, the commitment of the team to the project
2	Jung et al. (2016), Ameh and Osegbo (2011), and Jarkas (2015)	Location constraint of project, lack of proper planning, experience of the project team, tendency to pass on the blame to others
3	Dixit (2018), Dixit and Saurabh (2019), Shah et al. (2019), Dixit and Sharma (2019)	Management, technology, labour availability, climate, education and experience
4	Dixit et al. (2017)	Inaccurate productivity estimation of equipment, understanding of responsibilities by various project participants
5	Ameh and Osegbo (2011)	Managing emotions of the team, understanding of responsibilities by various project participants, social skills of key team managers
6	Jarkas et al. (2012) and Moselhi and Khan (2012, 2012)	unexpected weather condition, poor productivity of labour, inaccurate material estimate, selection of PM with a proven track record
7	Kadry et al. (2016) and Arditi et al. (2002)	Design variation, conflicts among various team members, use of inappropriate planning tools and techniques, timely decision by the owner

2.1.2 Delay in completion of projects

The completion of a construction project on time and within the budget is one of the main objectives of the construction manager/project manager. It is not that simple, however, because a construction project is like a living entity and requires the interconnection and coordination of several stakeholders and many of them have their objectives, which sometimes create a conflict of interest between the teams and within the teams. The success of any project is repeatable, and a set of attributes for the success of a construction project can be identified, requiring discipline and hard work.

2.1.3 Cost overruns of projects

Low labour productivity is of the utmost importance worldwide. Apart from all the leading technologies available from construction, a sufficient quantity of construction materials available in abundance, various tools to help workers, various financial institutions finance the project, contractors and subcontractors, it is evident that several projects have been delayed and therefore have exceeded their budgets (Ameh and Osegbo 2011; Apolot et al. 2011).

2.1.4 Construction project risk management

The construction industry has a fragmented nature, and it is necessary to identify the impact of the key factors associated with risk on construction projects so that the timely alternatives or solutions could be taken to avoid them. There are various risks factors globally associated with construction projects. The categories of risks related to clients, subcontractors, finance, contractors and government are common in nature (Ashly Babu and Kanchana 2014; Jayasudha and Vidivelli 2016). Construction work is potentially risky as compared to other sector jobs, making protection and compensation high.

2.1.5 Uncertain/unschedule activities

Uncertain activities endanger the safety of employees and impose severe penalties. Contractors should reduce risks and ensure that their employees comply with the necessary safety procedures. It is important to complete security compliance and inspection checklists to ensure that the necessary safety precautions have been adopted by the construction organisation (Hajdu 2015), which would help to reduce the risk of an accident and provides evidence to eliminate any liability from your business (Zhai et al. 2009; Kwon et al. 2014; Chancellor and Abbott 2015).

2.1.6 Integrated project delivery

Integrated project delivery (IPD) is gaining momentum as costs and time overruns become the norm of design. At the beginning of the project, the IPD has brought together a director, architect, contractor and main subcontractor to collaborate on designs, deadlines and costs. As the bulk of subcontractors operate on commercial projects, aligning their requirements with the owners and builders offers an effective and streamlined mechanism for the implementation of IPD employment.

2.1.7 Lack of communication

It is possible to overcome social issues by using technology. Through emails, text messages and on-site construction software applications, all team participants will immediately access information in real time and through immersive slowdowns and speed bumps (Abdul Kadir et al. 2005; Moselhi and Khan 2012; Chalker and Loosemore 2016; El-Gohary et al. 2017).

2.1.8 Planning

Planning can be challenging even for the most experienced construction practitioners. The new and modern project management tools could be adopted on laptop, smartphone or tablet to digitally map the job timeline. Some applications provide a form of “stick-note” virtual screen that help to easily view what needs to be completed and to track the progress of the project in real time (Isaac and Hajdu 2016).

2.1.9 The blame game

The fingers begin to point when the road bends. The developer general blames the subcontractor, the landlord blames the general contractor and the project manager blames the owner. When the worst-case scenario occurs, skip the blame game and point at the risk strategies of the developers. Such form of qualified property insurance and all the principals involved shall protect the policy (Dai et al. 2009; Best 2010; Panas and Pantouvakis 2015; Sezer 2015).

2.1.10 Few other issues

I. Size of the project undertaken
II. Project design complexities
III. Wearing site conditions such as soil drainage topography
IV. Weather conditions such as rain, summer, winter, and so on.
V. Seasons changes
VI. Manpower and labour conditions such as skilled and unskilled labour
VII. Government or regulatory requirements
VIII. Material source supply and Id's
IX. Complexity to transport and logistics
X. Design changes

3 Research methodology and data analysis

The research methodology provides a means of responding systematically to the research question and is designed to structure the research process into logical steps. The methodology adopted for the study is to identify and analyse the project performance attributes from the literature review and expert focus group interviews. The identified attributes were analysed and grouped using exploratory factor analysis (EFA). The data were collected using a structured questionnaire on pan India basis, and both online and offline modes of data collection were used. The collected data further analysed using SPSS 21 software. The quantitative research methodology was adopted to analyse the collected data, and the following tools and techniques were applied to the data: reliability analysis to check the consistency of data collected for the study and EFA to group the attributes into five main factors based on covariance. The questionnaire data collection was adopted because of the scarcity of the secondary data available on the research topic in the Indian scenario. The respondents selected for the study are directly associated to the Indian construction industry such as architects, clients, consultants, contractors, academicians, and other stakeholders. The questionnaire was floated to 53 construction projects in India. The respondents were selected irrespective of their gender, demography, and the type of projects to give an equal chance to the population. The finding of the study concludes that the respondents represent the industry and the different roles and responsibilities. The respondents were selected randomly, and the questionnaire was sent over mail to the respondents for seeking information on the study. The respondents were followed by three reminders to submit their responses. A total of 82 responses were received.

3.1 Position/designation of the respondents

A total of 37% of the respondents are working at the operational level, followed by middle management, top management, others (academician, NGO's, and other groups), and advisor/consultant level having the percentage share of 28, 17, 11, and 7%, respectively. If we club the top management and middle management, it becomes 45% of the respondents (Figure 1).

3.2 Years of respondents' experience

The respondents are having rich years of experience in assessing their material quality and their hard work when choosing the study sample, which enables the respondents to provide a simple and accurate description of the characteristics that affect construction efficiency and demonstrate the reliability and accuracy of the collected data (value of Cronbach's alpha for the current study is 0.81; Figure 2).

3.3 Factor analysis/principal component analysis

The concept of factor analysis techniques is that knowledge of the interdependence of the calculated variables can be used later to reduce the number of variables in the dataset. Factor analysis is frequently used in the fields of psychology, psychometry, personality theory, marketing, product management, behavioural science and

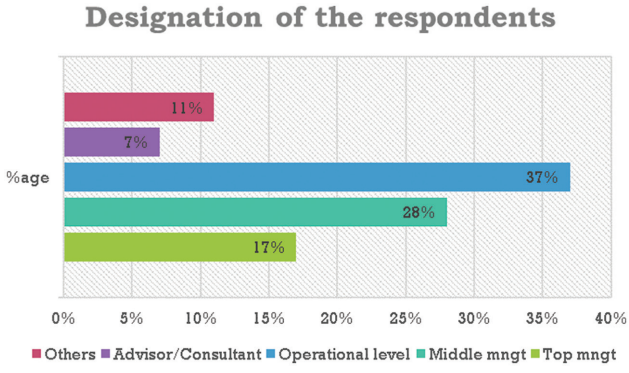

Fig. 1: Position/designation of the respondents.

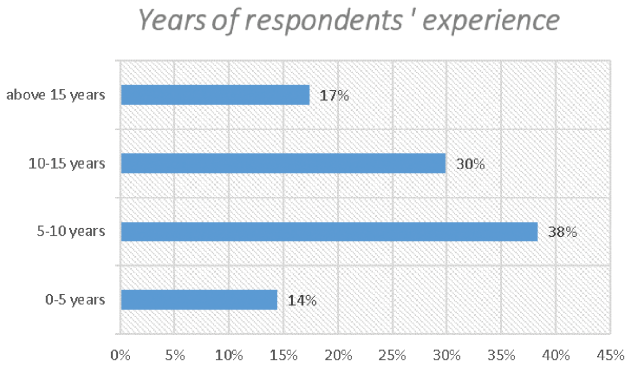

Fig. 2: Years of respondents' experience.

economics. It can help to manage data sets in which a large number of calculated variables represent fewer submissive/latent variables. It is one of the most widely used interdependence methods and is used when a specific set of variables exhibits structural interdependence and is designed to identify latent factors that cause commonality. The EFA reduced the 24 attributes into 5 factors (grouped into five factors based on covariance patterns available in the responses received from the respondents using maximum likelihood rotation). All the attributes selected into the factors are having a factor loading of more than 0.4. The total amount of variance explained by five factors is 54.5%, which is above the minimum threshold value required to proceed (above 50%). The maximum amount of variance is explained by factor 1 (site management and coordination) is 17.65%. The minimum value explained by a factor 5 is 7.5% (communication). All the five factors extracted from EFA are given in Table 2.

3.3.1 Site management and coordination

The first and main significant factor is site management and coordination, and it explains a maximum variance in all the other factors of 17.65% and having 06 attributes grouped. The attributes under the site management and coordination factor are shortage of materials, shortage of equipment, inaccurate productivity estimation of equipment, poor productivity of labour, design variation, and use of inappropriate planning tools and techniques sharing a factor loading of 0.65, 0.85, 0.80, 0.68, 0.85, and 0.67, respectively.

3.3.2 Leadership and financial management

The second factor is leadership and financial management, and it explains the variance of 11.8% and having 05 attributes grouped. The attributes under the leadership and financial management are the timely decision by the owner, tendency to pass on the blame to others, understanding of responsibilities by various project participants, conflicts among various team members, and interest and inflation rates sharing a factor loading of 0.48, 0.57, 0.57, 0.54, and 0.46, respectively.

Tab. 2: Exploratory factor analysis

Attribute/variable name	Factor loading	%age of variance explained
Site management and coordination		18%
Shortage of materials	0.65	
Shortage of equipment	0.85	
Inaccurate productivity estimation of equipment	0.80	
Poor productivity of labour	0.68	
Design variation	0.85	
Use of inappropriate planning tools and techniques	0.67	
Leadership and financial management		11.8%
The timely decision by the owner	0.48	
The tendency to pass on the blame to others	0.57	
Understanding of responsibilities by various project participants	0.57	
Conflicts among various team members	0.54	
Interest and inflation rates	0.46	
Planning		9.1%
Unexpected weather condition	0.55	
Inaccurate material estimate	0.79	
Location constraint of project	0.67	
Lack of proper planning	0.61	
Experience of the project team	0.55	
Commitment		8.5%
Selection of PM with a proven track record	0.49	
Willingness to adopt change	0.63	
The commitment of the team to the project	0.49	
Skilled labour	0.40	
Communication		7.5%
Understanding of responsibilities by various project participants	0.61	
Managing emotions of the team	0.40	
Social skills of key team managers	0.72	
Interpersonal skills	0.60	
Total variance explained		54.5%

3.3.3 Planning

The third factor is planning, and it explains variance of 9.1% and having 05 attributes grouped. The

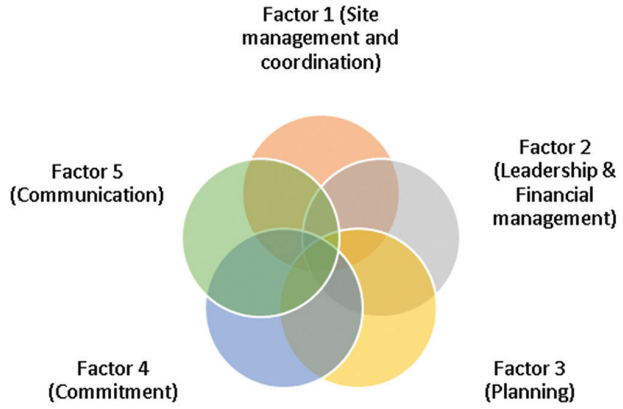

Fig. 3: Exploratory factor analysis.

attributes under the planning are unexpected weather condition, inaccurate material estimate, location constraint of project, lack of proper planning, and experience of project team sharing a factor loading of 0.55, 0.79, 0.67, 0.61, and 0.55 respectively.

3.3.4 Commitment

The second factor is commitment, and it explains variance of 8.5% and having 04 attributes grouped. The attributes under the Commitment are a selection of PM with a proven track record, willingness to adopt change, commitment of the team to the project, and skilled labour sharing a factor loading of 0.49, 0.63, 0.49, and 0.40 respectively.

3.3.5 Communication

The last factor is communication, and it explains variance of 7.5% and having 05 attributes grouped. The attributes under the communication are understanding of responsibilities by various project participants, managing emotions of the team, social skills of key team managers, and interpersonal skills sharing a factor loading of 0.61, 0.40, 0.72, and 0.60, respectively (Figure 3).

3.4 Reliability analysis/Cronbach's alpha for different factors

Reliability/consistency of the data for all the different factors are above 0.81, and as a rule of thumb, its value above 0.5 is accepted for the study (Doloi 2008). In the present study, the value is highly reliable and consistent (see Table 3).

Tab. 3: Reliability analysis/Cronbach's alpha for different factors

Factors	Cronbach's alpha	No. of attributes
Factor 1 (site management and coordination)	0.92	06
Factor 2 (leadership and financial management)	0.84	05
Factor 3 (planning)	0.81	05
Factor 4 (commitment)	0.90	04
Factor 5 (communication)	0.84	04

4 Discussion and conclusion

The construction industry in India is very complex, fractured, and largely unorganised. The performance of building projects has always been one of the most complex issues for the construction industry. Due to the unique nature of the work, planning, timely delivery, and reliability have always been subject to concern for the decision-makers. The construction industry has a fragmented nature associated with it. It is necessary to identify the impact of the key factors associated with risk on construction projects so that the timely alternatives or solutions could be taken to avoid them. This article highlights the importance of site management and coordination, leadership and financial management, planning, commitment, and communication in the performance of construction projects. This article also provides a guideline for the project managers to manage and improve the performance of construction projects by continuous monitoring and managing the identified five main significant factors in the Indian construction industry. The scope of the current study is limited to the Indian building industry, and the analytical unit chosen to conduct research and collect data at project/site level. Furthermore, the only building construction project has been finalised for the present study.

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