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Critical Analysis of Factors Affecting the on-site Productivity in Indian Construction Industry

Saurav Dixit[a]*, Satya N Mandal[a], Joseph V Thanikal[a] , Kinshuk Saurabh[b,]

[a]*RICS School of Built Environment, Amity University, 5th floor, F2 Block, Noida-201313, India*
[b]*Indian School of Business (ISB), Mohali, India*

Abstract

The growth in construction productivity is low and do not continue for a long span of time. The purpose of the present research paper is to identify the factors affecting the on-site construction productivity, from the literature review and through a focused interview with industry professionals. The most relevant 18 attributes have been finalized for the study, and a total of 154 complete data collection is targeted for the study form major contractors, developers and consultants throughout India. The convenient sampling technique is used to collect the data. The collected data has been analyzed using relative importance index (RII) to priorities the variable on the basis of their relative importance. The findings of the study conclude that the most significant 3 attributes affecting on-site construction productivity are planning and scheduling, availability of material, and storage area for a material having a relative value of 0.78, 0.76, and 0.75 respectively. SPSS 21 software tool has been used to check the reliability of the data and to perform factor analysis. The factors are site management, competency management, commitment and coordination management, resource management, and planning explains a variance of 15%, 11.5%, 10.3, 9.1, and 7.1% respectively. The research paper attempts to provide an insight and better understanding of the factors affecting on-site construction productivity in India and the ways and means to control and improve construction productivity of construction projects.

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Keywords: Construction Productivity; Construction Industry; On-site Productivity; Project Management; and Indian Construction Industry.

1. **Introduction**

Completion of a construction project on time and within budget is one of the main focus and key objective of a construction manager/project manager. It is however not that simple because a construction project is like a living entity and it requires interconnection and coordination of a number of stakeholders and many of them have their individual targets and goals, which sometimes create a conflict of interest between the teams and within the teams. The success of any project is repeatable and it is possible to find out a set of attributes for the success of a construction project and it requires a controlled discipline and hardworking. The productivity of construction projects is one of the measures for performance of the construction projects at the industry level based on its relationship with economic development. The most countries encounter the issue of low productivity as per the statistical data available in the public domain (OECD, report). The majority of the construction projects are suffering from two main issues those are delay in completion, and cost overrun. According to [1]–[5] poor productivity is one of the primary reasons for it. The productivity of a construction project is affected by a number of attributes either directly or indirectly. So the loss of revenues due to low on-site productivity of construction projects is one of the main areas of discussion for the researchers. And a number of researchers concluded that the productivity can be improved through

a proper control mechanism of the attributes affecting productivity. The current research focuses on identification, analyses and grouping of the critical factors affecting on-site construction productivity in the Indian context.

The construction industry is having a significant role in the nation's development and it contributes about 8-10 % to the nations GDP on an average[6]. The construction industry in any economy is considered to be one of the major contributors to the gross domestic product (GDP) of that country. The majority of the population is connected directly or indirectly to the construction industry for basic living infrastructures like housing, transport, hospitals, and schools. Indian construction industry is the 2nd largest contributor to the employment pool, after agriculture sector. Thereafter as emphasized before, the industry lacks largely in the area of integration work, hindering its performance and appreciation. The industry has a bad reputation due to insufficient customer satisfaction, its inability to meet time and cost estimates, lack of predictability and poor quality. Hence focus in recent research has shifted to what causes this problem.

The Indian construction industry has contributed to 8 percent on an average in the last five years of the Indian GDP (as per planning commission of India 12thfive year plan, 2015). The construction industry has around 31,000 enterprises and provides job to around 41 million employees and the Indian construction industry is second largest job provider after the agriculture sector [1]. As per 2011 census, 68% of the residential buildings are in rural areas and 32 % in urban areas. The number of people employed by the construction industry in India was 14.1 million in 1951 which increased to 41 million people in 2011, a 300 percent growth in employment observed in the last 6 decades in the Indian construction industry. Out of which 31000, estimated enterprises 95% of the enterprise operates on a small scale. Construction productivity can be defined the ratio of total output obtained per unit of input or it can be defined as the rate with which the work is performed in the project. In the construction industry output needed for productivity are in terms of weight, length, volume and the inputs are generally calculated in terms of man-hours or cost of labour.

1.1 *Construction Industry*

The construction industry is one of the most important and significant sectors and supports the economic development of a country. It contributes to the economy, promotes growth, provides employment to the masses, and established a linkage between the economy and other industries ([2] [3] [4]. The construction sector is the engine of growth for a country and creates a flow of services and goods with other sectors [5]. Improving construction productivity enables to save the cost of per capita and also increase the revenue of the firms. Increase in the revenues from improved CP provides an additional flow to the economy and as construction industry provides a linkage to all other industries as a part of their business process. The measures to be adopted to improve the performance of construction projects has been identified critical and troublesome problems [6]. [7].The construction industry faced a number of issues including low rates of productivity growth and declining growth that have been entertained by a number of researchers for many years [8]. The firms are aware of that issue and investing to know the reasons for declining the productivity [9].

1.2 Construction productivity

"In general terms, construction productivity can be simply illustrated by an association between an output and an input i.e. Productivity= Output/Input". Productivity is commonly defined as a ratio of a volume measure of output to a volume measure of input use (OECD Manual) [10]. The productivity could be measured at various levels, but there are three main measures of productivity are metronomic, case, and pricing studies [11]. The financial wealth of nations is determined by their productivity growths (Smith, 1776). The nations experienced higher productivity growth translated into increases in the average wages of the workers, which contributes to the profits and tax revenue collection of the countries [11]. Researcher's tried to understand the relationship between skill development and productivity in the construction industry. The trend is not consistent over time due to a number of reasons such as unplanned training sessions, consistency of skill development courses and the decrease in the number of participants [12][13]. Construction productivity has been the area of interest for the research since last 4-5 decades. A number of studies have been conducted in the field which includes: analysis of productivity, measurement techniques, and

causes of low productivity, factors affecting construction productivity, simulations models, a framework for improving CP and other studies

2. **Literature review**

Productivity has been one of the most researched topics in the Indian construction industry in the last few decades. Factors affecting productivity may have a short-term or long-term effect on the project, some affect the productivity for a short duration but have a ripple effect on it. Productivity consists of various attributes like labour, finance, infrastructure, plant & machinery, facilities etc. Various studies in different countries have been carried out to identify the factor affecting labour productivity. Various methodologies and approaches have been adopted by researchers who have come with different schemes in the categorization of factors affecting productivity [10]11]. [12]Classified factors affecting productivity into internal and external factors. Internal factors were termed for those factors which are beyond the control of management and External factors for those factors which arise or originate in and around the workplace. [7] Introduces a regression model that established a linking between worksite productivity to process improvement initiatives (PII). This model provides insight and helps the industry to predict the expected value of productivity at the beginning of the project on the basis of certain inputs such as design competition, project manager's dedication, project vision and others. The model was created specifically from temporary worker particular data and subjected to thorough factual investigation. The model gives project supervisors as front-line industry workers to ponder and reasonable way to deal with project management and productivity improvement. [8] Has studied the impact of poor productivity of construction workers on the cost and delay of the projects. And the findings suggest that cost and timely completion of any Project is significantly dependent on the workforce productivity. Analytical hierarchy process used to prioritise the factors affecting workforce construction productivity and the finding suggests that major significant factors are planning and schedule related. A number of researcher's identified and analyzed the factors affecting CP in different scenario's and ranked them on the basis of their severity of impact and relative importance index values derived using different approaches such as: reliability importance index, some statistical tools, analytical hierarchal analysis, principal component analysis or factor analysis, SOM-based models, system dynamics based approaches, and other tools and techniques[9] [10] [11] [12] [13] [14] [15] [16] [17] and [18].

Table 1 attributes affecting on-site construction productivity

Attributes/variables	*References*
Increases in land-use regulation	[19]
Equipment, drawing, tools, availability of material, weather condition	[20], [14],[21], [22]
Labour management, rework, material, confined working space, tools	[23], [24]
Delays in inspection, decision taking, material, rework, tools and equipment	[24]–[26]
Absenteeism, Rework and lack of material	[9][27], [12] [28] [11][29] [15] [9][30]
Shop drawings, equipment's, motivation and support, scheduling, material	[31] [8], [23], [32], [33][34]
Revision in drawings, delays in inspection, competency of supervisor, martial availability	[24] [27], [29]-[15], [35][36][6]
Project management, planning and scheduling, top management support, rework	[7], [37],[38]
Coordination among all team members, leadership, top management support, the flow of funds, budget update, coordination and communication, timely feedback, and owner's competence and favourable climatic condition.	[39][40], [41]
Rework, Poor supervisor competency and Incomplete drawings	[24], [42], [43] [23], [35], [37] [44]
Decision making, planning & logistics, supply chain management, labour availability, budget & cash flow management, improper construction method, frequent changes in design, supervision delay, the sequence of activities, overcrowding a job location and scope of activities.	[40], [13][32] [45][41]
Availability of material, the experience of labour, skill set and training, communication, the financial position of the client	[33][32], [14]

Table 2 findings of previous studies (attributes affecting construction productivity)

References	*Findings (ranking of the attributes)*

[9] and [10]	Availability of material	Drawing management	Coordination	Construction equipment	Tools and consumables
[11]	rework	truck availability	Materials	equipment	Tools
[12] and [13]	Management	technology	labour availability	climate	education and experience
[14]					
[15]	Labour skills	coordination	supervision errors	drawings	delay in response to information
[46]	Temperature	height			
[16]	The findings of the study suggest that craft labour productivity shall be improved using material tracking technologies.				
[18]	The authors proposed and validate a SOM-based model to analyse the relationship between crew productivity and various factors.				
[17]	The authors identify and measure a four-component decomposition of the temporal changes in construction labour productivity, including technology, technology-utilization efficiency, the capital-labour ratio and production capacity.				
[47]	The findings of the study suggest a consistent decline in the productivity of output /labour/hour				
[40]	The findings of the study suggest that high sustainable productivity shall be achieved under good management practices				

3. **Data collection**

To achieve the desired objective the data for the study were collected through a structured questionnaire survey of 112 construction professionals and academicians from all over India. The questionnaire consists of 21 questions attempting to cover the major factors affecting on-site productivity. The factors have been identified with the help of various studies on construction labour productivity. People with required qualification and experience answered the questionnaire, so it can safely be assumed that the data obtained has credibility and can be used for the study as the respondents are conversant with the problems related to labour productivity and factors affecting the construction productivity.

3.1 Relative importance index

The received responses by the respondents were summarized in an Excel data sheet and the data analysed using SPSS software. Relative importance indices (RII) is performed to determine the priority of the significant factors and then followed by Reliability analysis performed to check the consistency of the data received.

$$\text{Rii} = \frac{\sum_{r=1}^{5} r * n_r}{5N} \quad (1)$$

'r' is the rating on a Likert scale (1-5) as for the impact on construction efficiency for a specific element influencing construction profitability, 'n' is the number of respondents providing a specific Likert scale rating r, 'N' is the aggregate number of respondents to a specific question [6].The respondents were asked to rate the questions using a five-point scale '5' being the very high, '4' high, '3' moderate, '2' low, '1' very low impact on on-site productivity.

3.2 Reliability Cronbach's alpha value

Dependability analysis is required to check the consistency of the data, and Cronbach's alpha test was the best way to check the reliability of the data collected through questionnaire [29]. The value of Cronbach's alpha for this study is 0.715 which is considered to be good (table 3) [29].

Table 3reliability/Cronbach's alpha for the attributes

Description	Cronbach's alpha
All attributes selected for the study	0.715

4. **Result and findings**

4.1 Most significant factors

The most significant factors affecting the on-site productivity in Indian construction projects are planning and scheduling, availability of material, and storage area for material [48] having a relative importance index of 0.78, 0.76, and 0.75 respectively (table 2).

4.2 Significant factors

The significant factors affecting the on-site productivity in Indian construction projects are frequent changes in drawings, periodic meetings among management and contractor 's, and change in scope [49][50] having a relative importance index of 0.74, 0.73, and 0.70 respectively(table 2).

Table 4 ranking of attributes on the basis of relative importance index

Rank	*Total Responses*	*Total Score*	*RII*	*Attributes affecting the on-site productivity of construction projects*
1	112	435	0.78	Planning and scheduling
2	112	428	0.76	Availability of material
3	112	421	0.75	Storage areas for materials
4	112	415	0.74	Frequent change in drawings
5	112	408	0.73	Periodic meetings with management, Site personnel and contractors
6	112	393	0.70	Change in scope
7	112	389	0.69	Job Security/appreciation
8	112	386	0.69	Pep talk
9	112	383	0.68	Working Condition/Confined space
10	112	372	0.66	Type of Construction Methodology
11	112	371	0.66	Absenteeism
12	112	369	0.66	Adequate Crew and composition
13	112	368	0.66	Proper timely inspection by engineer
14	112	367	0.65	Rework
15	112	364	0.65	Proper training provided prior to execution of work
16	112	362	0.65	Poor construction method
17	112	357	0.64	Direction and coordination/communication
18	112	356	0.63	Experience of Management

Table 5 factors analysis

Attribute/Factor	*Factor loading*	*%age of variance explained*
Site management		*15%*
Training	0.53	
Availability of material	0.84	
Working condition	0.57	
Working hours	0.65	
Competency management		*11.5%*
Rework	0.46	
Poor construction method	0.55	
Job security	0.59	
Commitment and coordination		*10.30%*
Response to change order	0.55	

Revision in drawings	0.79	
Pep talk	0.61	
Periodic meetings with management and site personals	0.55	
Resource management		*9.1%*
Storage area for material	0.49	
Adequate crew and composition	0.63	
Planning		*7.1%*
Change in scope	0.49	
Project management	0.63	
Total variance explained		*53.3%*

4.1 Factor analysis

Factor analysis enables us to reduce the number of dimensions of the data and to draw a table on the basis of variance explained by the constructs/factors, and factor loading of the different attributes in factors. For the current study, the attributes having a factor loading of equal and more than of 0.4 has been considered[8]. The factor analysis reduced 18 attributes into 5 factors explain a cumulative variance of 53.3%.

4.1.1 Site management

Pre-construction management explains the maximum variance of 15% for the attributes affecting on-site CP. The attributes having the factor loading more than 0.4 are training, availability of material, working condition, and working hours having a factor loading of 0.63, 0.84, 0.57, and 0.65 respectively.

4.1.2 Competency management

Decision management explains a variance of 11.5% for the attributes affecting on-site CP. The attributes having the factor loading more than 0.4 are rework, poor construction method, and job security having a factor loading of 0.46, 0.55, and 0.59 respectively.

4.1.3 Commitment and coordination

Stakeholder's management explains a variance of 10.3% for the attributes affecting on-site CP. The attributes having the factor loading more than 0.4 are a response to change order, revision in drawings, pep talk, and periodic meetings with management and site personals having a factor loading of 0.55, 0.79, 0.61, and 0.55 respectively.

4.1.4 Resource management

Coordination and communication explain a variance of 9.1% for the attributes affecting on-site CP. The attributes having the factor loading more than 0.4 are a storage area for material, and adequate crew and composition having a factor loading of 0.49, and 0.63 respectively.

4.1.5 Planning

Resource management explains a variance of 7.1% for the attribute affecting on-site CP. The attributes having the factor loading more than 0.4 change in scope, and project management having a factor loading of -0.61, and 0.4 respectively.

CONCLUSION

The study aims to identify and analyze the factors affecting the on-site productivity in construction project through an empirical study. The study reveals that the average value of reliability analysis for all the attributes is above 0.63 i.e. all the attributes selected for the study having a significant impact on on-site productivity. The most significant attributes impacting on-site productivity are planning and scheduling availability of material, and storage area for materials. The maximum variance is explained by site management, and the least variance explained by planning is 15%, and 7.1% respectively. This study reveals the main factors affecting on-site productivity in India through a structured questionnaire survey. The results of the study shall benefit the industry to improve their productivity.

Limitations

The study is conducted using structured questionnaire survey and collection of primary data. The received responses are 112 considered for this study is comparatively small to generalize the findings to the larger scale. It is recommended to conduct a similar kind of study in different regions of the country to have a better understanding of the factors affecting on-site productivity in construction projects.

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