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Research Paper

Project-level Factors Influencing the Performance of Building Construction Operations in Sri Lanka: Viewpoint of Engineers and Construction Managers

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Abstract

Productive-based project-level operations are the lifeblood for the construction sector, leading the firms to achieve their expected profitability and long-term sustainability. Past studies highlight the poor project-level practices resulting in productivity loss in many developing countries, including Sri Lanka. It is essential for construction management teams to have a proper controlling hand on the project-level factors that influence construction productivity. The engineers and construction managers are the key decision-makers in construction project activities. This study aimed to quantify the impacts of project-level factors on the productivity of construction operations in Sri Lankan building projects based on the viewpoint of engineers and construction managers. Initially, the project-level factors were qualitatively identified through a comprehensive literature review. A questionnaire survey was carried out among engineers and construction managers from 90 leading Sri Lankan building construction contractors. The Relative Importance Index (RII) method was used to measure the impacts of the project-level factors on construction productivity. The results spotlight the need for reinforcing the current planning and monitoring practices from construction management teams focusing on construction methods, working conditions, scheduling and sequencing of construction tasks, health and safety practices, quality control practices, reworks, labour skills improvement and workforce overtime. The statistical assessments ensured the reliability and validity of the results. In addition, a series of industry consultative workshops and discussion sessions were conducted among construction experts through problem-based communication approaches to identify future actions in the construction project planning processes. These discussion outcomes also ensured the validity of the above results. The study outcomes will push the construction management practices to reduce the conflict situations between the project-level activities in different stages, leading to the achievement of organizational goals. Although the study findings are limited to the Sri Lankan context, some findings may be tested in other developing countries in similar scenarios.

Keywords: Building projects, construction management, productivity improvement, Sri Lanka

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Introduction

Construction is an indispensable sector for the national socio-economic goals of a country [1]. The productivity improvement in various construction operations is the crucial area for achieving the expected profitability from any construction project [2]. In general, it is important to have a good controlling hand on the project-level factors that influence the productivity of construction operations [3-5]. Mojahed and Aghazadeh [6] reveal that the project-level factors are mainly based on labour-related operations, and some of these factors are beyond the control of job site management, but many of these factors can be controlled through job site efforts.

In the recent past, several studies have focused on the performance of labour operations in the construction industry around the world. Studies highlight that the labour performance differs based on the types of construction operations [7-10], project size [4], site layout [3, 5] and site locations [11]. The changes in site layouts and site locations cause unrealistic project schedules [12] and make the contractors choosing unusual construction methods [2].

Poor construction methods and poor working conditions have been the problems for the construction firms in many countries [2, 13-15] against improving the productivity of labour operations. Healthy construction methods and work conditions have a significant impact on labour morale. These reduce the chances of workplace injuries along with resulting financial liabilities and the need to take time off. The construction workers need to follow proper health and safety practices throughout the construction operations [10, 16, 17]. Past studies highlight the lack of health and safety practices in the construction industry of many countries, including Australia [3], Egypt [4], India [18, 19], Nigeria [20] and South Africa [21]. A significant number of cases were reported due to accidents and labour injuries in many construction projects in Australia [3], India [18, 22] and South Africa [23].

Praveen et al. [24] found that time overrun and cost overrun had a significant impact on the labour performance in many construction projects in Sri Lanka. This was also reported in Iran [5] and South Africa [23]. The time overrun causes the improper working time of labour operations which may also be one of the reasons for the low performance of labour [25]. Oke et al. [23] stated that the less number of labourers working in construction projects has been a significant factor for the low productivity in the construction sector of South Africa. On the other hand, an excessive number of labourers was also reported that significantly affected the labour productivity in the construction projects in Iran [5]. Workforce overtime and rework were also the other significant factors highlighted by Shahab and Audrius [5]. The same problems were also reported by Durdyev et al. [26], considering the industry practices in Turkmenistan. Work overtime may increase body mass index and alcohol consumption, which may lead to many other health problems. Working for long hours may also harm the mental health of labourers [27].

The extent of variation and design complexity/changes were determined that significantly influenced the performance of labour operations in the construction projects in India [28] and Kuwait [29]. Clarity of the drawings and project documents [3, 12, 30, 31], high mobility [17], quality inspection delays [3, 18, 32] and unavailability of utilities [33] are the other project-level factors that have a significant impact on labour performance in construction.

Overall, the current study comprehensively reviewed the past studies that investigated the project-level factors influencing the construction operations in different countries, as shown in Table 1.

Table 1. Past Studies that Investigated the Labour Productivity in Different Countries

Country	Studies
Australia	[3]
Egypt	[4, 34]
India	[2, 10, 13, 15, 16, 18, 19, 22, 28, 33, 35, 36, 37, 38]
Indonesia	[32, 39]
Iran	[5, 8, 9]
Kuwait	[29]
Malaysia	[40, 41]
New Zealand	[42, 43]
Nigeria	[14, 17, 20, 44, 45]
Palestine	[30, 46]
Qatar	[47]
South Africa	[21, 23, 48]
Spain	[31]
Sri Lanka	[1, 49, 50, 51, 52, 53]
Trinidad & Tobacco	[12]
Turkey	[54, 55]
Turkmenistan	[26]
United Arab Emirates	[25]
Vietnam	[56]
Zimbabwe	[57]

Sri Lankan Context (Manoharan et al. [53])

Considering the Sri Lankan construction sector, only a few studies have investigated the factors affecting labour performance in construction. Among those, the findings of Manoharan et al. [53] are significant for understanding the current status of the industry practices. Manoharan et al. [53] have identified the factors that significantly affect the performance and productivity of labour operations in the Sri Lankan construction industry through comprehensive approaches. Considering the project-level construction operations, a total of 24 factors were presented by the study [53], as shown in Table 2. The study [53] comprehensively reviewed the potential research articles in accordance

with their reputation and impact ratings as proposed in the methodology by Schweber and Leiringer [58]. Since there were not many recent studies that investigated labour performance in the Sri Lankan construction sector, considering the importance of understanding the current practices of the industry, the experts' interviews were also encompassed in [53], covering the construction operations of all types of construction projects, including building, road/highway, bridge, water supply and irrigation works. The thematic analysis method was applied in [53] to qualitatively produce the significant factors, which are shown in Table 2. The mapping of those 24 factors with other studies from foreign contexts is also shown in Table 2.

Table 2. Project-level Factors Affecting Labour Performance in Construction Presented by Manoharan et al. [53]: Mapping with Other Past Studies from Different Countries

Code	Factors	Past Studies from the Countries (shown in Table 1)																		
		Australia	Egypt	India	Indonesia	Iran	Kuwait	Malaysia	Nee Zealand	Nigeria	Palestine	Qatar	South Africa	Spain	Sri Lanka	Tritad & Tobacco	Turkey	Turkmenistan	United Arab Emirates	Vietnam
P1	Project size		X																	
P2	Poor site layout	X				X														
P3	Site location														X					
P4	Type of construction process			X		X														
P5	Unrealistic schedule			X	X	X		X			X					X		X		
P6	Sequence of the work			X		X														
P7	Poor construction methods			X		X			X	X										
P8	Poor working conditions			X					X	X										
P9	Lack of health and safety practices	X	X	X						X			X							X
P10	Accidents and labour injuries	X		X									X		X					
P11	Work at heights		X	X																
P12	Excessive number of labourers					X														
P13	Less number of labourers			X									X		X					X
P14	Workforce overtime			X		X									X			X	X	
P15	Rework	X		X	X	X		X	X		X	X	X					X		
P16	Improper working time			X											X					
P17	Time overrun					X							X		X					
P18	Cost overrun														X					
P19	Extent of variation			X			X													
P20	Design complexity and changes			X			X						X							
P21	Clarity of the drawings and project documents	X			X									X		X				
P22	High mobility									X										
P23	Poor quality assurance and quality control in construction	X		X	X						X									
P24	Unavailability of utilities			X																

Importance of this Study

Overall, studies highlight that there is an essential need for upgrading the current project-level practices towards the performance improvement of construction labour operations in many developing countries. In the Sri Lankan construction sector, the construction of buildings plays a significant role in the industry since a large number of building projects are ongoing on different scales with high investments. The engineers and construction managers are the working resources who can play a central role in decision making processes to upgrade the project-level practices in construction operations. This study aims to quantify the impacts of project-level factors that influence the performance and productivity of labour operations in the Sri Lankan building construction projects at the current scenario based on the perspectives of engineers and construction managers. This will be very useful to the construction sectors of many developing countries for taking necessary steps to improve their current practices related to project-level operations.

Materials and Methods

Quantitative approaches were used to measure the impact levels of the project-level factors (shown in Table 1) on the performance and productivity of labour operations based on the viewpoint of engineers and project managers. The study also included comprehensive approaches to test the validity and reliability of the findings. The following sections describe those.

Questionnaire Survey

A questionnaire survey was carried out among building construction contractors in Sri Lanka. A total of 90 contractors participated in this survey, where the engineers and construction managers represented their firm to respond to the survey questions based on their current project-level practices. The Likert scale of five ordinal measures from 1 to 5 (very low effect to very high effect) was used in the survey questions for indicating the impact levels of the factors on labour performance and productivity. The experts'

interviews were conducted among some engineers and project managers at the initial stage of the survey to validate the designed questionnaires.

Considering the difficulties in deciding the actual sample size with the target characteristics, the survey respondents were identified using the snowball sampling method as recommended by Showkat and Praveen [59]. The snowball sampling method defines the process of expanding the sample size through a small population from the initial stage of the survey. The survey was limited to the upper graded contractors registered in the Construction Industry Development Authority (CIDA) of Sri Lanka. In Sri Lanka, CIDA is the authorized body, which recognizes the contractors' registration in the construction field. According to the National Registration and Grading Scheme for Construction Contractors of CIDA, 11 grades are used to categorize the contractors based on their financial capacity, technical ability, and experience gained in the field. Here, C4 is the middle-level grade of CIDA registration, and the minimum financial limit to obtain this grade is 50 million Sri Lankan Rupees. Though the technical and financial abilities vary between different grades of contractors, consultations with the technical and project management service units of CIDA revealed that there are no significant differences in the current project level practices among the upper graded contractors.

Table 3 shows the detailed profile of responded contractors based on their experience in the building construction field and the CIDA registration grades. Among the survey participants, 98% had a minimum of 5 years of work experience, where the majority (around 40%) was in the range of 5-10 years. Referring to the CIDA registration grades, the highest percentage of respondents were C4 grade contractors. It is noted that more than 20% of contractors who participated in this survey were from the building construction projects where billions of Sri Lankan Rupees were invested.

Table 3. Detailed Profile of Survey Respondents

Profile	Variables	No. of Responses	Percentage
Experience in the construction field	Less than 5 Years	02	02%
	5–10 Years	35	39%
	11–15 Years	21	23%
	16–20 Years	11	12%
	21–25 Years	13	14%
	More than 25 Years	08	09%
CIDA Grade of Contractors (Financial Limit of the Projects - LKR in Million)	CS2 / CS1 (X > 1500)	07	08%
	C1 (1500 >= X > 600)	15	17%
	C2 (600 >= X > 300)	19	21%
	C3 (300 >= X > 150)	11	12%
	C4 (150 >= X > 50)	38	42%

Quantitative Analysis

The Relative Importance Index (RII) method was applied to measure the impact levels of each project-level factor on the productivity and performance of labour operations. Equation (1) was used to calculate RII, as recommended by past studies [29, 50].

$$\mathrm{RII} = \frac{\sum \mathrm{W}}{\mathrm{A} * \mathrm{N}} \qquad (1)$$

- W represents the weight assigned to each factor by response ranges (1 – Very low, 2 – Low, 3 – Moderate, 4 – High, 5 – Very high).
- A represents the maximum weight given (A equals 5).
- N represents the total number of responses.

The higher RII value illustrates that the corresponding factor has a high impact on the performance and productivity of labour operations. The minimum RII value to decide the corresponding factor as critical was 0.7. The Coefficient of Variation (CV) values were also calculated for each factor to test the reliability of the results. According to Solly and Gezani [60], the CV value can be defined as the ratio between standard deviation and RII

values. Here, the smaller CV value indicates that the values given by the respondents are around the mean values. According to Statistics Canada [61], the CV value should not exceed 0.3 to ensure the reliability of the result.

Industry Consultative Meetings and Workshops

A series of discussion sessions and industry consultative workshops were conducted among construction experts from various working categories to discuss the impact levels of the identified critical factors on labour performance and productivity. Problem-based communication approaches were mainly used in the discussion sessions to determine the actions that need to be taken in the construction planning and management practices. The results were also validated through these discussion outcomes.

Results and Discussion

Based on the perspectives of engineers and construction managers, the impact levels of the project-level factors on labour performance and productivity in building construction projects are shown in Table 4. Among those 24 factors, 11 factors were determined as critical based on their RII values (more than 0.7). This section discusses those critical factors comparing with the previous findings in Sri Lankan and other foreign contexts, also describing the reasons for the current status of those factors, how those are linked with other factors and the required actions in the industry activities.

Table 4. Impact Levels of the Factors on Labour Productivity

Codes of Factors	Mean	RII	SD	CV	Ranking	Level of Impact
P7	3.93	0.79	0.14	0.18	1	High
P8	3.90	0.78	0.15	0.18	2	High
P5	3.82	0.76	0.16	0.23	3	High
P6	3.74	0.75	0.15	0.22	4	High
P4	3.73	0.75	0.19	0.22	5	High
P13	3.69	0.74	0.15	0.22	6	High
P23	3.66	0.73	0.16	0.19	7	High
P24	3.66	0.73	0.15	0.20	7	High
P9	3.63	0.73	0.15	0.20	9	High
P15	3.60	0.72	0.12	0.17	10	High

P14	3.50	0.70	0.14	0.22	11	High
P10	3.49	0.70	0.16	0.20	12	Medium
P16	3.49	0.70	0.12	0.16	12	Medium
P17	3.47	0.69	0.11	0.17	14	Medium
P21	3.44	0.69	0.12	0.17	15	Medium
P2	3.43	0.69	0.18	0.18	16	Medium
P3	3.42	0.68	0.14	0.19	17	Medium
P11	3.34	0.67	0.15	0.18	18	Medium
P20	3.34	0.67	0.14	0.18	18	Medium
P22	3.30	0.66	0.12	0.18	20	Medium
P1	3.14	0.63	0.16	0.21	21	Medium
P18	3.10	0.62	0.17	0.21	22	Medium
P12	3.04	0.61	0.15	0.19	23	Medium
P19	3.02	0.60	0.12	0.17	24	Medium

Poor Construction Methods and Poor Working Conditions

The study reports that the construction methods and working conditions in many building construction projects have a significant impact on the performance and productivity of labour operations in Sri Lanka. The poor construction methods and poor working conditions have also affected the labour productivity levels in other countries, namely India [2, 13, 15, 62], Nigeria [14] and New Zealand [42]. Considering the Sri Lankan context, the industry consultative experts specifically pointed out the following factors related to materials/tools resulting in poor construction methods and working conditions in many construction operations.

- Material shortages and delivery delays
- Improper material selection and changes in material types
- Costs of some materials
- Poor quality of materials
- Poor quality and maintenance of working tools
- Tool delays and breakdowns
- Equipment shortages
- Poor skills of equipment operators

The above factors were also highlighted by Kesavan et al. [63], resulting in poor construction methods and construction delays. This confirms the lack of industry's focus on improving the practices related to material and tool handling in recent scenarios in Sri Lanka. Kesavan et al. [63] also highlighted that the contractors' financial difficulties, poor communication between parties, unclear/inadequate details in drawings, frequent change of sub-contractors, poor technical skills of contractors' staff and delays in site mobilization are the reasons for the main contractors following poor construction methods and work conditions.

Unrealistic Schedules, Sequences of Construction Tasks and Types of Construction Processes

The study highlights the significance of construction planning practices in scheduling and sequencing construction activities to obtain higher productivity in construction. Past studies also revealed that labour performance has been affected due to unrealistic project schedules in construction projects in many countries [5, 26, 32, 64]. Proper project scheduling is important for a productive operational workflow. It improves work efficiency, effective materials management and proper distribution of resources leading to reduce cost and time.

Based on the current industry practices in Sri Lanka, the industry consultative experts also stated that the delays in obtaining permits/approvals from relevant authorities and the changes in government regulations also result in unrealistic project planning and scheduling. Kesavan et al. [63] highlighted the problems related to sub-contractors that affect the project schedules and sequence of main construction activities, which are frequent change of sub-contractors, conflicts in sub-contractors schedule and delays in subcontractors' work. Rework due to errors during construction was also reported by Kesavan et al. [63] as an influential factor on the project schedules and sequence of construction tasks.

Less Number of Labourers Involving Construction Activities

The study results confirm the labour shortage affecting the productivity of construction activities in Sri Lankan building construction projects. In recent scenarios, the labour shortage caused productivity-related issues in the construction sectors of many other countries, including India [15, 33], South Africa [21, 23] and Vietnam [56]. Considering the Sri Lankan context, the labour shortage has been a significant problem for the contractors and contributed to construction delays [50]. The industry consultative experts stated that the skills shortage has been the major reason for the fewer labourers involving in many construction operations in the Sri Lankan construction industry. Due to the skills shortage, unskilled labourers work as skilled labourers in many construction projects in Sri Lanka [1, 52], and this significantly affects the quality and productivity of construction operations. The experts also highlighted the following factors affecting job interest, motivation and work satisfaction of Sri Lankan labourers in construction.

- Salary delays and low salaries
- No labour rewarding mechanisms
- Lack of proper incentives
- Improper promotion opportunities
- Fewer welfare facilities for labourers
- Lack of job security for labourers

Poor Quality Assurance and Controlling Practices in Construction; Lack of Health and Safety Practices

This study highlights the poor quality assurance and control practices in Sri Lankan building construction projects. The industry consultative experts also stated that many Sri Lankan construction firms do not follow proper quality assurance and control policies in their work practices. Industry consultative experts and past studies [65-67] revealed

that the school education and vocational training programmes do not consist of sufficient components related to quality assurance and control practices in construction. They also reported the lack of components for health and safety-related construction practices in those curricula. Poor health and safety practices resulted in many workplace injuries in construction projects in Sri Lanka. Workplace injuries have been a significant factor that contributed to the construction delays in Sri Lanka [50].

Reliability and Validity of the Findings

The reliability and precision of the findings were ensured based on the CV values of the factors. According to the range mentioned in the Labour Force Survey Guide 2020 of Canada [61], the CV values of all factors were within the allowable limit (less than 0.3). In addition, the outcomes of the problem-based discussions among industry experts ensured the validity of the study findings.

Conclusion

The study has identified the critical project-level factors that affect the labour productivity in Sri Lankan building construction projects based on the viewpoint of engineers and project managers. The impact levels of the factors show how much attention needs to be considered for each component of project-level practices in order to improve the productivity of construction operations. The study also presented why those factors are critical and how those influence the various project-level tasks in the construction phase. The significant findings of this study have been extensively compared with the past studies from Sri Lanka and other foreign contexts. The validity and reliability assessments on the study findings also resulted positively through comprehensive approaches.

The study has displayed the areas in project-level practices under the construction phase, where the improving practices are required to take on by the construction management

team. The study also highlighted the specific need for upgrading the vocational training programmes in the country, strengthing the learning components related to quality assurance and controlling, health and safety, material handling and equipment handling.

The overall study outcomes will be useful for construction management teams to reduce the conflict situations between the project-level tasks in different stages, leading the industry activities towards long-term sustainability. The study also recommends future studies focus on improving quality assurance and safety management practices during the construction stage. The study findings are limited to the Sri Lankan building construction project-level practices. But, some of these findings may also be useful for the other developing sectors to upgrade their current project-level practices towards the improvement.

Conflict of Interest

No potential conflict of interest was reported by the authors.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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