Research Article   **Open Access**

The Influence of Labour Competencies on the Efficiency of Road Construction Operations in Sri Lanka

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Abstract

Background: The successful completion of a construction project is largely dependent on the efficiency of labour. But, low efficiency of labour operations is the biggest problem faced by the construction sector in emerging nations like Sri Lanka. Many previous studies highlight that competencies of labour have a significant impact on how well construction operations are executed. However, studies that focus on efficiency improvement in road construction project operations are lacking in the Sri Lankan construction industry, even though both the public and private sectors invest more in road construction as a part of the development process of the nation's infrastructure. Accordingly, this study intended to pinpoint the crucial competencies of labourers that have a significant impact on how well road construction projects in Sri Lanka operate.

Methods: The significant knowledge and skill elements were qualitatively identified through literature surveys and interviews. A total of 40 scholarly articles were included in the literature survey. The collected data was analysed using the qualitative thematic analysis. A questionnaire survey was conducted among 39 road construction contractors who were identified using the snowball sampling method. The relative importance index (RII) method was used to determine the influence level of those elements on the efficiency of road construction projects.

Results: A total of 27 causes were found to be critical, where the top five ranking labour-related criteria were found to be the lack of thinking abilities, lack of knowledge in construction works, communication issues, lack of labour morale/commitment and labour discipline. Through statistical testing, the validity and reliability of the study findings were confirmed.

Conclusions: It is strongly advised to take the crucial labour competencies found in this study into consideration, to improve and enhance the construction labour force in the industry. The study findings are anticipated to be extremely helpful in similar circumstances for the Sri Lankan construction sector as well as other growing construction industries.

Keywords: Construction Industry, Labour Skills, Road Projects, Sri Lanka

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INTRODUCTION

Various studies highlight that a nation's economy heavily depends on the construction sector [1-4]. Due to the potential of the human population, the economy is growing more productive, inventive and competitive. The use of the labour force is the key element for effective completion of any construction project. One of the most challenging issues with human resources in the construction sectors, particularly in developing nations, is the poor efficiency of labour [1].

Most construction workers in developing nations typically originate from low-income families with little formal education [2-3]. Their work processes and outputs are influenced by a variety of factors [1-3]. Their levels of competencies need to cover a wide range of work processes. Therefore, the development of labourers' competencies might enhance their efficiency [3]. The competencies of labourers can be improved by enhancing practices in the areas of education and training, working conditions, health care facilities, motivating elements, tool and material use, job quality and other aspects that are relevant to the construction work [1, 4].

Fernando *et al.* [2] has emphasised the skill shortage of labourers as one of the significant issues in construction projects from a Sri Lankan perspective. According to the Tertiary and Vocational Education Commission of Sri Lanka's Construction Industry Sector Training Plan 2018-2020 [3], cognitive, soft and job-specific technical skills have been identified to be limited among construction labourers. This has also been confirmed by the Construction Industry Sector Council (CISC) and Industry Sector Skills Councils (ISSC) of Sri Lanka.

Numerous studies reveal that the Sri Lankan labourers' competencies have not been at an adequate level for enhancing the efficiency of construction project operations [2-3]. The construction sector can greatly benefit from identifying the essential competencies of workers affecting efficiency with severity measurements in order to take the appropriate actions for improvement. Notably, consultations with representatives of the Sri Lankan Construction Industry Development Authority (CIDA) have revealed that both the public and private sectors invest more in road construction as a part of the nation's infrastructure development and that there is a lack of studies focused on the labour-related skills influencing road project operations in Sri Lanka. Accordingly, this study aims to investigate how the competencies of labourers are affecting the efficiency of road construction project operations in Sri Lanka. This may help the construction sector of a developing nation like Sri Lanka in tackling the efficiency and productivity-related challenges linked to the modernisation of construction site practices.

Many studies have investigated the knowledge bases, skills and performance of construction labourers around the world [1-7]. Patel *et al.* [4] has examined the factors influencing labour performance in the construction industry using a systematic analysis of recently released research articles. The primary element that affects labour efficiency in the construction industry has been identified as the inadequate cognitive skills of labourers in applying construction methods and techniques [4]. Regarding the construction projects in India, Iran and New Zealand, respectively, Soham and Rajiv [5], Parviz and Mohammed [6] and Serdar and Jasper [7] have brought attention to the same issue.

From the project manager's perspective, it has been discovered that the workers need to pay greater attention to their health and safety procedures in the State of Queensland, Australia [19]. Regarding the construction projects in Nigeria, Peter *et al.* [20] and Oseghale *et al.* [21] have brought attention to the same issue. Soham and Rajiv [5], Shahab and Audrius [22], and Abdulaziz *et al.* [23] have reported that the labourers'

cognitive skills in health science and their physical ability are quite inadequate in many construction projects in India, Lithuania, and Qatar, respectively.

Oseghale *et al.* [21] has assessed the skilled labour supply in the Nigerian construction industry and indicated that their labourers' technical skills need to be enhanced. Meanwhile, the need to increase the Sri Lankan labourers' technical drawing comprehension and material handling skills has been highlighted by Praveen *et al.* [24]. However, a limited number of studies have examined the competencies of labourers in the Sri Lankan construction industry. This study sought to better the efficiency of road construction projects by identifying the major competencies of Sri Lankan labourers using qualitative and quantitative methodologies.

MATERIALS AND METHODS

Preliminary Survey
In order to qualitatively identify the critical competencies of labourers affecting the efficiency of road construction operations in Sri Lanka, a preliminary survey was carried out using a comprehensive literature review and a series of structured interviews.

Literature Survey
A comprehensive literature review was conducted by considering 40 scholarly studies from 18 different nations, as indicated in Table 1. Out of them, eight studies in total were based on the Sri Lankan viewpoint. Table 2 displays the number of research publications reviewed based on the published period. Notably, it shows that more than 80% of these articles were published in the last decade, whereas around half of them were released within the latter half of the last decade.

According to their reputation, impact rankings and subject contents, the majority of these research publications were initially chosen by well-known online search engines such as 'Google Scholar', 'ResearchGate', 'ScienceDirect' and 'Scopus'. Some of the articles were located on the basis of the

suggestions made by the subject matter experts. The article titles, abstracts and keywords were carefully scrutinised. Following a thorough review process, a table was created to compile the information gathered from the literature study.

Table 1: Number of Studies Reviewed based on the Country

Country	Number of Studies
India	10
Sri Lanka	8
Nigeria	3
South Africa	3
Indonesia	2
Egypt	2
Australia	1
Iran	1
Lithuania	1
New Zealand	1
Palestine	1
Qatar	1
Singapore	1
Spain	1
Trinidad & Tobago	1
Turkey	1
UK	1
Vietnam	1

Table 2: Number of Studies Reviewed based on the Published Period

Study Period	Number of Studies
2016 - 2020	16
2011 - 2015	17
2006 - 2010	4
2001 - 2005	1
Up to 2000	2

Preliminary Survey
Construction specialists from the Sri Lankan construction sector participated in structured interviews to identify the most recent practices in the sector. These interviews included 42 construction industry

professionals in total, representing different fields, as shown in Table 3. Participants in these interview sessions included directors, project managers, engineers, quantity surveyors and institutional specialists from training providers, supervisors and technical officers. Notably, 15 interviewers in total had experience working with foreign labourers.

Table 3: Number of Interviewed Construction Experts based on their Years of Experience

Years of Experience in the Construction Field	Number of Interviewed Construction Experts
Less than 5 Years	-
5 – 10 Years	16
11 – 15 Years	04
16 – 20 Years	07
21 – 25 Years	03
More than 25 Years	12

Thematic Analysis
On the competencies of labourers that were identified from the preliminary survey, a thematic analysis was conducted as recommended by Caulfield [25]. It is a technique for qualitative analysis where the data is studied to find recurring themes like topics, ideas and patterns. The competencies identified from the preliminary survey were examined for specific characters, and the codes were issued as necessary.

The associated codes were then established between the groupings of competencies discovered through literature reviews and interviews based on the themes developed. According to the identified associated codes, the repetition of competencies was eliminated. The final collection of competencies was derived from this qualitative analysis after a second assessment of the themes and codes.

Questionnaire Survey
To assess the severity of the selected competencies of labourers influencing the efficiency of labour in road construction projects, a questionnaire survey was conducted among Sri Lankan road construction contractors. A total of 39 road construction contractors were chosen using the snowball sampling technique due to the challenges in finding the genuine sample size with the required attributes [26]. Only the construction contractors who work on projects having a minimum Construction Industry Development Authority (CIDA) registration grade of 'C4' were taken into account in this survey.

The CIDA in Sri Lanka grants the essential grades for a contractor's registration based on the contractor's financial availability, technical proficiency and work experience. Between 50 million and 150 million Sri Lankan Rupees are the permitted financial limits for the 'C4' grade [27]. The Table 4 illustrate the number of replies received based on the contractor's level of CIDA registration.

Table 4: Number of Responses based on the Contractor's Grade of CIDA Registration

CIDA Grade	Financial Limit of the Projects (X: LKR in Million)	Number of Responses
CS2 / CS1	$X > 1500$	04
C1	$1500 >= X > 600$	03
C2	$600 >= X > 300$	07
C3	$300 >= X > 150$	04
C4	$150 >= X > 50$	21

The respondents were classified into two working categories based on their employment titles, which are Director/ Managerial/ Engineer (DME) level and Assistant Engineer/ Supervisor/ Technical Officer (AST) level. Accordingly, 54% of the respondents were working in the DME level, whereas 46% of them were from the AST category. Table 5 shows their profile based on their work experience in the construction field.

Table 5: Number of Responses based on the Respondents' Work Experience

Experience in the Construction Field	Number of Responses
Less than 5 Years	01
5 – 10 Years	16
11 – 15 Years	10
16 – 20 Years	8
21 – 25 Years	4
More than 25 Years	0

The prepared questionnaire contained the competencies that were determined from the preliminary survey of this study. A Likert scale with five ordinal measurements ranging from 1 to 5, was used to base the questions (1 represents the very low effect and 5 represents the very high effect). Before the commencement of the survey, cognitive interviews were conducted with five construction experts for their feedback on the prepared questionnaire to validate the questionnaire design.

Relative Importance Index (RII)
The influence level of each detected competency on the efficiency of road construction operations was determined using the Relative Importance Index (RII) technique. According to Dinh and Nguyen [28], this can be determined for each element using the Equation 1.

$$RII = \Sigma W/(A * N) \qquad (1)$$

Where, W: Weight assigned by response ranges (1 – Very Low, 2 - Low, 3 - Moderate, 4 - High, 5 - Very High); A: Maximum weight given; N: total number of responses. To determine the extent of the effects of competencies, the following RII value ranges were taken into account. The competencies were deemed critical, if their RII values were 0.7 or above.

RII >= 0.9   : Very High (VH)
0.9 > RII >= 0.8   : High (H)
0.8 > RII >= 0.7   : High – Moderate (HM)

0.7 > RII >= 0.6   : Moderate (M)
0.6 > RII >= 0.5   : Moderate – Low (ML)
0.5 > RII >= 0.3   : Low (L)
0.3 > RII   : Very Low (VL)

To assess the accuracy of the findings, standard deviation, coefficient of variation and margin of error values were also computed for each competency element. The lower standard deviation suggests that the respondents' values are close to the mean [29]. The error margin values of competencies were computed for a 95% confidence interval.

Statistical Analysis
The degree of agreement between DME level and AST level working categories on the competencies of labourers in Sri Lankan road construction projects was determined using Spearman's coefficient of rank correlation. As per the recommendations of recent studies [30-31], this can be determined using the Equation 2.

$$\rho = 1 - [6\,\Sigma D^2/n(n^2 - 1)] \qquad (2)$$

Where, ρ: Spearman's coefficient of rank correlation; D: Difference between the ranks of two variables; n: Number of observations. To determine the effects of the degree of agreement, the values of Spearman's coefficient of rank correlation were investigated in the following ranges.

ρ > 0   : Positive degree of agreement (Positive relationship)
ρ = 0   : Neutral (No correlation)
0 > ρ   : Negative degree of agreement (Negative relationship)

RESULTS AND DISCUSSION
In the preliminary survey, more than 85% of the respondents concurred that the cognitive components of Sri Lankan labourers are currently insufficient. Meanwhile, 90% of the interviewees stated that the manual skills of Sri Lankan labourers are currently insufficient for enhancing the efficiency of construction operations. Most importantly, the majority of interviewees claimed that

inadequate training facilities are not being offered by construction organisations to develop the competencies of labourers. Based on the RII values of each competency element, which are displayed in Table 6 and Table 7, the level of effect for each competency element of labourers was calculated. The findings indicate the degree to which each competency element of labourers has an impact on the performance level of the road construction projects in Sri Lanka.

Overall, the critical competencies of labourers influencing the efficiency of road construction project operations in Sri Lanka included 18 knowledge domains and 30 skills/abilities. The labourer's cognitive abilities in numeracy, understanding basic structures, performing simple measurements, applying construction methods, procedures and technology and material handling were found to be in the top five ranked components in the knowledge category, while their attitude, punctuality and their communication, measuring and problem-solving skills were at the top five in the category of skills/abilities (Table 8).

Table 6: Ranking of Cognitive Components of Labourers Working in the Sri Lankan Road Construction Projects

Knowledge Areas	Statistical Values					
	RII	SD	CV	ME	#	LE
Numeracy	0.80	0.16	0.20	0.03	1	H
Basic structures	0.79	0.15	0.19	0.03	2	HM
Simple measurements	0.78	0.15	0.19	0.03	3	HM
Construction procedures and technology	0.78	0.16	0.21	0.02	3	HM
Construction materials	0.76	0.12	0.16	0.03	5	HM
Material handling	0.76	0.15	0.20	0.02	5	HM
Equipment handling	0.76	0.12	0.16	0.02	5	HM
Quality assurance and control	0.75	0.14	0.19	0.02	8	HM
New technologies in construction	0.75	0.16	0.21	0.03	8	HM
Health & Safety in construction	0.75	0.15	0.20	0.03	8	HM
English / Languages other than mother tongue	0.73	0.12	0.16	0.02	11	HM
Financial knowledge	0.72	0.14	0.19	0.02	12	HM
Basic labour laws and regulation	0.72	0.14	0.19	0.02	12	HM
Simple architecture	0.71	0.15	0.21	0.02	14	HM
Estimation	0.71	0.12	0.17	0.02	14	HM
Health science	0.70	0.14	0.20	0.03	16	HM
Psychology	0.70	0.14	0.20	0.02	16	HM
Information and communication technology	0.70	0.12	0.17	0.02	16	HM
Environmental sustainability	0.69	0.13	0.19	0.02	19	M
Drawing	0.69	0.16	0.23	0.03	19	M
Waste management	0.66	0.13	0.20	0.02	21	M
Environment & Society	0.66	0.17	0.26	0.03	21	M
Basic electricity	0.65	0.16	0.25	0.03	23	M
Water management	0.63	0.16	0.25	0.03	24	M

Note: RII: Relative Importance Index; SD: Standard Deviation; CV: Coefficient of Variation; ME: Margin of Error; #: Rank; LE: Level of Effects; VH: Very High; H: High; HM: High – Moderate; M: Moderate; ML: Moderate to Low; L: Low; VL: Very Low

Table 7: Ranking of Skills and Abilities of Labourers Working in the Sri Lankan Road Construction Projects

Skills/Abilities	Overall					
	RII	SD	CV	ME	#	LE
Attitude	0.87	0.16	0.18	0.03	1	H
Measuring	0.85	0.16	0.19	0.03	2	H
Problem solving	0.84	0.17	0.20	0.03	3	H
Punctuality	0.84	0.15	0.18	0.03	3	H
Communication	0.84	0.17	0.20	0.02	3	H
Decision making	0.83	0.17	0.20	0.03	6	H
Leadership	0.83	0.18	0.22	0.03	6	H
Reading, writing and listening	0.83	0.14	0.17	0.03	6	H
Commitment	0.83	0.13	0.16	0.02	6	H
Attendance	0.83	0.15	0.18	0.03	6	H
Learning	0.82	0.19	0.23	0.03	11	H
Memorization	0.82	0.16	0.20	0.03	11	H
Planning	0.81	0.12	0.15	0.02	13	H
Reduction of alcohol and drugs usage	0.81	0.11	0.14	0.02	13	H
Math and language literacy	0.80	0.17	0.21	0.02	15	H
Estimating	0.80	0.15	0.19	0.03	15	H
Analytical skills/abilities	0.79	0.13	0.16	0.02	17	HM
Critical reasoning	0.78	0.12	0.15	0.03	18	HM
Ability to understand drawings	0.78	0.16	0.21	0.03	18	HM
Understanding with other workers	0.77	0.15	0.19	0.02	20	HM
Multiple work coordination	0.77	0.14	0.18	0.02	20	HM
Skills in team work	0.76	0.18	0.24	0.03	22	HM
Equipment / Tool handling	0.76	0.12	0.16	0.02	22	HM
Material handling	0.75	0.13	0.17	0.02	24	HM
Physical ability	0.74	0.12	0.16	0.02	25	HM
Psychology	0.72	0.13	0.18	0.03	26	HM
Management & Organisational skills	0.71	0.11	0.15	0.02	27	HM
Innovative	0.71	0.12	0.17	0.03	27	HM
Concreting	0.71	0.18	0.25	0.03	27	HM
Ability to adapt to changes and new environments	0.70	0.15	0.21	0.02	30	HM

Note: RII: Relative Importance Index; SD: Standard Deviation; CV: Coefficient of Variation; ME: Margin of Error; #: Rank; LE: Level of Effects; VH: Very High; H: High; HM: High – Moderate; M: Moderate; ML: Moderate to Low; L: Low; VL: Very Low

Table 8: Ranking of Skills and Abilities of Labourers Working in the Sri Lankan Road Construction Projects

	Rank	Competency Elements	Past Studies
Knowledge	1	Numeracy	Tertiary and Vocational Education Commission [3]; Praveen *et al.* [24]
	2	Basic structures	Tertiary and Vocational Education Commission [3]
	3	Simple measurements	Soham and Rajiv [5]; Praveen *et al.* [24]; Dolage *et al.* [32]
	4	Construction methods, procedures and technology	Patel *et al.* [4]; Soham and Rajiv [5]; Parviz and Hosseini [6]; Serdar and Jasper [7]
	5	Material handling	Praveen *et al.* [24]; Dolage *et al.* [32]
Skills / Abilities	1	Attitude	Soekiman *et al.* [33]; Dharani [17]; Fernando *et al.* [2]; Orando and Isabirye [14]; Dinh and Nguyen [28]
	2	Measuring	Soham and Rajiv [5]; Praveen *et al.* [24]; Dolage *et al.* [32]
	3	Problem solving	Tertiary and Vocational Education Commission [3]; Lim and Jahidul [11]
	4	Punctuality	Fernando *et al.* [2]; Brent and Leighton [12]; Orando and Isabirye [14]; Dharani [17]; Shashank *et al.* [34]
	5	Communication	Robles *et al.* [13]; Rami and David [19]

Degree of Agreement between the Levels of Workers

The findings of the Spearman's rank coefficient of correlation showed that in the cognitive domains of labourers, DME level and AST level personnel had a degree of agreement (positive association) of 78.0%. They agreed (have a favourable relationship) to an extent of 91.1% with respect to labourers' skills and abilities. The findings showed that there are not many conceptual distinctions between DME level workers and AST level workers on the identified critical competencies for labourers.

Validity/Reliability of the Findings

The reliability and accuracy of the results were guaranteed by the standard deviation (SD) and coefficient of variation (CV) values of competencies, as shown in Table 6 and Table 7. For all categories of competencies, the CV values were below 0.3. These CV values ensured that the validity and reliability of the findings were at a suitable level for the purpose of this study, according to the Labour Force Survey Guide-2020 of Canada [36]. The degree of agreement found between the two working categories' observations on the KSAs further supports the trustworthiness of these results.

CONCLUSIONS

Current study pinpointed the key areas of labourers' competencies that should be taken into account in improving the efficiency of construction operations in Sri Lankan road projects. Overall, the findings indicated that a wide range of cognitive and self-management

abilities of labourers need to be improved more than their transferable and technical skills. The study also emphasised the urgent need to enhance the training programmes for the construction labourers employed in the Sri Lankan road projects. Based on the crucial competencies discovered from this study, essential workplace training activities and experimental exercises should be established to apply improved practices to labour operations.

These findings will be useful for developing new training programmes based on industry needs, particularly for establishing learning outcomes, learning materials and training delivery strategies. This study suggests creating a suitable mechanism to assess labour capabilities on the job sites of Sri Lankan construction firms. The labourers in Sri Lanka should receive more attention from construction organisations in terms of performance evaluation techniques and practices for their skill enhancement. The results of this study are anticipated to be extremely helpful to Sri Lankan construction firms, skill development agencies and training organisations in order to take the essential activities for improvement. Other emerging construction organisations could test some of these findings in comparable circumstances. This study recommends to conduct more studies on enhancement of procedures based on the crucial competencies of labourers depicted in this article.

CONFLICT OF INTEREST
No potential conflict of interest was reported by the authors.

AUTHORS' CONTRIBUTIONS
KM: Conceptualized, designed the research, carried out the investigation, performed data curation and analysis, and wrote the manuscript. PD: Supervised the study and reviewed the manuscript. CP: Supervised the study and reviewed the manuscript. DD: Supervised the study and reviewed the manuscript. RS: Supervised the study and reviewed the manuscript.

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