SEUSL

Sri Lankan Journal of Technology

Research

SLJoT
2023 Issue 1 18 - 28
ISSN 2773-6970

The Impacts of Critical Construction Supervisory Competencies on the Efficiency, Productivity and Sustainability of Road Construction Operations in Sri Lanka

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Received: 14-12-2022 * Accepted: 10-06-2023 * Published Online: 30-06-2023

***Abstract*—Supervision practices play a crucial role in acting as a bridge between labour and organisations in construction. According to sources, the progress of construction projects is negatively impacted by the inadequate competencies of construction supervisors in developing nations like Sri Lanka. This study aims to pinpoint the critical supervisory competencies that affect the efficiency, productivity and sustainability of road construction operations. Qualitative and quantitative methods were applied to determine the essential supervisory competencies of the construction industry. To analyse the necessary actions, industry-expert discussions were held using problem-focused communication approaches. In total, 17 cognitive elements and 25 skills/abilities of construction supervisors were identified as being crucial according to their impact values, with the top-ranking cognitive domains for construction supervisors being basic concepts of structures and performance evaluation of labour skills, followed by their manual skills/abilities in labour management and communication. A list of anticipated key competency outcomes was presented for assisting the development processes of new productive construction supervisory training components. Pertinent statistical analysis results and the industry consultation outcomes assured the validity and dependability of the overall findings. The results demonstrate how the significant construction supervisory competencies impact the efficiency and sustainability of road construction operations with the necessary quantitative measurements, and these results will be highly useful to the industry sector skill enhancement authorities/boards as they update their training development practices intending to enhance the sustainability and work culture of construction project operations. The study findings have greatly influenced how the industry re-skills and up-skills workers in terms of supervision, work culture, efficiency, sustainability and productivity management. While Sri Lankan road construction projects were the study's primary focus, some of the findings will also be tested in situations similar to those in other developing construction industries worldwide.**

***Keywords*—**Construction Supervision, Work-based Competencies, Productivity Improvement, Training Design, Road Projects

I. Introduction

A nation's gross domestic product is significantly influenced by the productivity growth of the construction industry (Durdyev and Mbachu, 2011). By generating a wide range of investment opportunities, the construction industry significantly aids in the achievement of the socio-economic goals of a country (Shahab and Audrius, 2018). Importantly, numerous studies point out that the construction sector employs the most people over the longest period of time compared to other sectors (Manoharan *et al*., 2021b). Consequently, labour efficiency and productivity have considerable impacts on how successful construction projects are (Mistri *et al*., 2019; Shahab and Audrius, 2018). However, the construction sector of most developing countries has been facing many difficulties related to financial flows, competitiveness and stakeholder proposals due to the low productivity and efficiency of labour operations (Dinh and Nguyen, 2019). As a result, construction companies encounter a number of issues associated with time overruns, cost overruns and inadequate work outputs (Silva *et al*., 2018).

Construction supervisors serve as a vital link between labour and organisations in general by using effective supervision practices to manage labour operations in construction activities (Onyekachi, 2018). But in recent decades, many countries, including New Zealand (Durdyev and Mbachu, 2011), Trinidad and Tobago (Hickson and Ellis, 2013), Australia (Hughes and Thorpe, 2014), Iran (Ghoddousi *et al*., 2015), Nigeria (Onyekachi, 2018) and Sri Lanka (Manoharan *et al*., 2022), have attributed the low productivity and poor work culture among labour in the construction industry largely to the insufficient competencies of construction super-

visors. Relevant studies highlight even more the necessity of developing new skills in the labour supervision role in order to put effective methods for controlling labour operations at worksites into practice (Onyekachi, 2018; Montaser *et al*., 2018; Manoharan *et al*., 2022). It is important to remember that work-based training components are the anchored learning tasks connected to regular work practice in order to increase employability, work readiness and applications to address issues related to job roles and specific careers of workers (Manoharan *et al*., 2021a). There is a scarcity of studies that focused on developing apprenticeship protocols for systematically upgrading the site supervision practices connecting with labour work process and outputs in the construction sector of many developing countries similar to the Sri Lankan setting. Consequently, identifying the crucial competencies of supervisory workers that influence labour efficiency and productivity in construction is necessary for the construction sector of many developing nations.

According to the aforementioned factors and the gaps, this study aims to identify the crucial construction supervisory competencies that influence the efficiency, productivity and sustainability of labour work outputs in Sri Lankan road construction operations. The following are the study's objectives in order to reach the stated aim and address the gaps.

- Identify the competency factors/elements associated with supervision that influence the work output of labour in Sri Lankan road project operations qualitatively
- Quantify the extent to which those factors influence the work output of labour in Sri Lankan road construction projects
- Determine the future steps that the appropriate authorities must take to enhance the practices currently employed in the supervision

The above-stated research process will help the construction industry in many developing nations overcome productivity barriers, poor working culture/patterns and sustainability issues caused by the changes in the industry's challenges and opportunities. Notably, consultations with representatives of the Sri Lankan Construction Industry Development Authority (CIDA) regarding the Sri Lankan construction industry stated that both the public and private sectors invest more in road construction as part of the nation's infrastructure development and that there is a lack of studies focused on the supervisory skills and work culture influencing road project operations.

Recent studies have revealed a variety of skills that need to be concerned for enhancing the working culture/patterns of construction supervisors in various nations (Hickson and Ellis, 2013; Oseghale *et al*., 2015; Saurav *et al*., 2017; Onyekachi, 2018; Montaser *et al*., 2018; Murari and Joshi, 2019). One of the key factors that significantly affect labour productivity in construction projects in Trinidad and Tobacco is the construction supervisors' ability to manage the sites (Hickson and Ellis, 2013). Notably, a survey conducted by Jarkas *et al*. (2012) among 84 construction firms in Qatar found that leadership skills are a determining factor in the site management practices of construction supervisors. Strong decision-making and leadership skills enable supervisory workers to receive higher work outputs from their workforce. However, the supervisors working on various construction projects in Kuwait (Jarkas and Bitar, 2012) and India (Saurav *et al*., 2017) were found to lack these skills. Durdyev and Mbachu (2011) found that the main factors limiting on-site labour productivity in the New Zealand construction industry were the supervisors' site coordination skills. They were also identified more than ten years ago as a significant source of delays controlling the productivity of construction operations in Malaysia (Kadir *et al*., 2005). In order to coordinate labour and material resources during construction activities and to maximise resource utilisation, site coordination is essential (Kadir *et al*., 2005).

Construction supervisors' interpersonal skills were examined in a survey conducted by Onyekachi (2018) among 49 Nigerian construction firms. It was found that the leadership, planning and communication skills of construction supervisors are the key elements that significantly influence the sustainable work culture in construction operational flows. Onyekachi (2018) also draws attention to how the poor relationship between Nigerian construction site managers and workers affects the effectiveness of work operations. Notably, improved communication between supervisory staff and labourers results in labour engagement and higher motivation, which in turn boosts sustainability in the industry (Onyekachi, 2018). Further, it has been discovered that one of the key performance indicators of construction supervisors that has considerable impacts on workforce productivity in a large number of Indian construction projects is planning skills (Murari and Joshi, 2019). Effective construction planning increases productivity, efficiency and resource management techniques to reduce costs and project delays (Kesavan *et al*., 2014). On the other hand, the ethical behaviour of supervisory staff significantly influenced the workflows and patterns of job operations in a notable number of construction projects in Iran (Ghoddousi *et al*., 2015). Honesty, integrity, fairness and many other virtues are the key components of ethical behaviour that ensure sustainable practices in workflows. As stated by Mahan (2019), when managers behave ethically, the level of commitment and satisfaction of workers to performance enhancement will significantly increase.

Hughes and Thorpe (2014) aimed to comprehend how Queensland-based project managers viewed the factors affecting construction productivity. It shows how much the construction supervisors' skills in the areas of health, safety and quality inspection need to be improved. On the other hand, there have been numerous reports of poor quality control abilities from construction supervisors in India (Shashank *et al*., 2014). Hughes and Thorpe (2014) point out that quality control practices have a significant impact on workplace safety and the risk of costly mistakes. Furthermore, Oseghale *et al*. (2015) claimed that the construction supervisors' poor

Table I: Mapping of significant cognitive elements of construction supervisors affecting the efficiency and productivity of construction operations based on past studies

Cognitive Elements (Knowledge in)	Past Studies															
	Dinh and Nguyen (2019) - Vietnam	Murari and Joshi (2019) - India	Montaser *et al.* (2018) - Egypt	Onyekachi (2018) - Nigeria	Silva *et al.* (2018) - Sri Lanka	Dixit *et al.* (2017) - India	Fernando *et al.* (2016) - Sri Lanka	Kesavan *et al.* (2015) - Sri Lanka	Hughes and Thorpe (2014) - Australia	Robles *et al.* (2014) - Spain	Shashank *et al.* (2014) - India	Jarkas *et al.* (2012) - Qatar	Adi and Ni' am (2012) - Indonesia	Jarkas and Bitar (2012) - Kuwait	Durdyev and Mbachu (2011) – New Zealand	Soekiman *et al.* (2011) - Indonesia
Construction methods and technology				X												
Construction materials			X													
Equipment handling	X		X													
Quality assurance and control									X		X					X
Health and safety in construction	X		X						X		X					
Site management						X					X					
Resource management																X
Waste management							X									
Water management							X									
Construction planning		X				X				X						
Performance evaluation on labour skills							X									
Industrial research													X			
Modern technologies in construction					X											
Environment and society										X	X					

Table II: Mapping of significant skills/abilities of construction supervisors affecting the efficiency and productivity of construction operations based on past studies

Skills/Abilities	Past Studies															
	Dinh and Nguyen (2019) - Vietnam	Murari and Joshi (2019) - India	Montaser *et al.* (2018) - Egypt	Onyekachi (2018) - Nigeria	Silva *et al.* (2018) - Sri Lanka	Dixit *et al.* (2017) - India	Fernando *et al.* (2016) - Sri Lanka	Kesavan *et al.* (2015) - Sri Lanka	Hughes and Thorpe (2014) - Australia	Robles *et al.* (2014) - Spain	Shashank *et al.* (2014) - India	Jarkas *et al.* (2012) - Qatar	Adi and Ni' am (2012) - Indonesia	Jarkas and Bitar (2012) - Kuwait	Durdyev and Mbachu (2011) – New Zealand	Soekiman *et al.* (2011) - Indonesia
Labour management						X					X				X	
Site management and coordination						X				X	X		X	X	X	
Planning		X		X		X				X						
Supervision of operations			X						X	X		X		X	X	X
Resource management																X
Leadership				X								X				X
Decision making						X										
Relationship with labourers				X												
Performance evaluation on labour skills							X									
Quality inspection									X		X					X
Ability of conducting industrial research													X			
Participation																X
Motivational skills								X								

cognitive skills in health and safety procedures were the main obstacles to productivity improvement for Nigerian construction contractors.

Soekiman *et al*. (2011) identified quality control, leadership and resource management as the crucial supervisory skills that influence the efficiency of the work operations in Indonesian construction projects. Adi and Ni'am (2012) stated that construction supervisory staff in the Indonesian construction industry need to enhance their abilities in conducting industrial investigations. Supervisory staff will be capable to identify workplace problems and take immediate action to address them by conducting such investigations towards the enhancement of sustainable work culture and flows.

Taking on the Sri Lankan context, there were not enough studies that focused on improving construction supervision practices when it came to the construction sector of the country. According to Fernando *et al*. (2016), many Sri Lankan construction firms lack focus on sustainable practices that need to be applied to labour supervision and work operations. In Sri Lankan construction projects, it was discovered that the cognitive capabilities of construction supervisors in health and safety were a significant factor affecting labour productivity (Halwathura, 2015). As per the recent studies

in the Sri Lankan context (Halwathura, 2015; Manoharan *et al*., 2020), supervisory workers' abilities in conducting performance evaluations of labour skills at work sites need to be specifically concerned by the industry to address the challenges related to labour skill shortage.

Based on previous studies, Table I and Table II display the mapping of significant construction supervisors' knowledge and skills/abilities that have notable effects on the efficiency and productivity of construction operations.

II. Materials and Method

In order to determine the critical supervisory competency elements influencing the efficiency, productivity and sustainability of road construction operations, both qualitative and quantitative approaches are included in the study methodology. In-depth approaches were also used in the study to evaluate the reliability and accuracy of the findings. These are covered in the sections that follow. The methodological progression used in this study is depicted in Figure 1.

A. Literature Investigation

A comprehensive literature review was conducted by reviewing pertinent scholarly academic articles from numerous nations, as shown in Figure 1. On the basis of their reputation, impact rankings and subject contents, popular online search engines were initially used to find the majority of the academic articles. Some of the articles were also found based on suggestions from the subject matter experts. After carefully reviewing the article titles, abstracts and keywords, a table was created to compile the data discovered during the literature study.

B. Interviews

Sri Lankan construction experts took part in structured interviews to learn about the most recent procedures in the sector. In total, interviews with more than 20 construction industry professionals were conducted. Team leaders, project managers, engineers, quantity surveyors, institutional specialists from training providers and technical officers were present during these interview sessions, taking into account the professional backgrounds of those interviewed. All the interviewees had at least five years of job experience in the construction sector, and most had job experience between five and ten years. Almost all the interviewees concurred that the skills of construction supervisory workers are insufficient to improve the effectiveness of road project operations in Sri Lanka under the current circumstances.

C. Qualitative Thematic Analysis

For the purpose of qualitatively identifying the major supervisory competencies influencing the efficiency, productivity and sustainability of road project operations, the data from the literature and expert interviews were subjected to thematic analysis. Using a collection of qualitative data, thematic analysis is a recognised technique for examining respondents' perspectives, knowledge, experiences or values (Caulfield, 2019). This method was used to look for recurring themes, subjects, concepts and patterns in the data that had been gathered. The identified competencies were examined in this qualitative thematic analysis process for specific characters, and the codes were issued as necessary. The associated codes between the groups of competencies discovered through literature reviews and interviews were then established based on the themes created. The associated codes were used to prevent competencies from being repeated. This qualitative analysis resulted in the final set of competencies after a second assessment of the themes and codes. Figure 2 shows the sequential processes of the qualitative thematic analysis employed in this study.

D. Quantitative Analysis

To determine the degree to which the identified supervisory competencies have an impact on road construction operations, a questionnaire survey was administered to 39 road construction contractors in Sri Lanka. Since it was difficult to calculate the exact sample size given the needed features, the snowball sampling approach was employed to choose the respondents for this survey. The snowball sampling technique is a non-probability method for deciding survey sample sizes, and it can be used when it is challenging to find potential participants (Showkat and Praveen, 2017). The survey's sample size was first increased by identifying a small number of well-known contractors, and then it was expanded by identifying additional contractors who participated.

Regarding the design of the questionnaire, it was split into two sections, with the first section covering the backgrounds of the respondents and the second one containing the significant competencies discovered through the qualitative process. Using a Likert scale with five ordinal measures, survey respondents were asked to rate the influence levels of each competency element on the efficiency, productivity and sustainability of road project operations. Importantly, the necessary instructions and details were provided in the questionnaire to ensure that the respondents understand and are aware of the scope of the study with the aspects related to the significance of productivity, efficiency and sustainability in operational construction practices. Furthermore, six survey participants took part in cognitive interviews during the initial phase to verify the accuracy of the questions that were developed for the questionnaire design.

In this survey, only road construction contractors who work on projects with a minimum CIDA registration grade of 'C4' were considered. According to the financial capability, technical competence and work experience of contractors, the Construction Industry Development Authority (CIDA) assigns the necessary grades for contractors' registration in Sri Lanka. The acceptable financial limits for the 'C4' grade as being 50-150 million Sri Lankan Rupees, as mentioned by Construction Industry Development Authority (2014). This survey received responses from 39 Sri Lankan road construction contractors. Regarding the distribution methods, the majority of the questionnaires were obtained by a direct

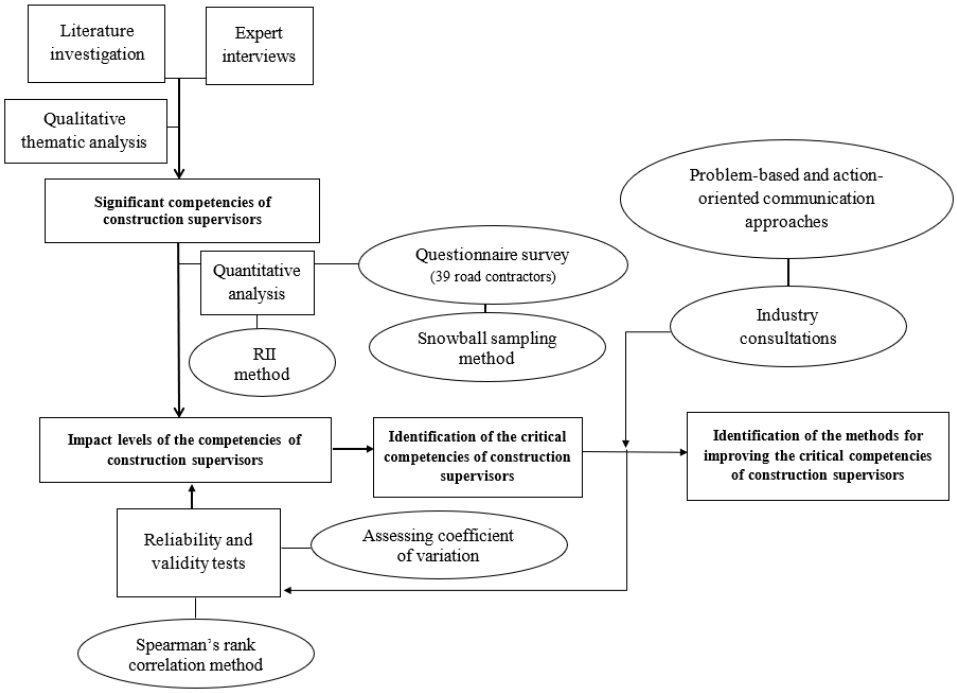

Figure 1: Sequential process of the study methodology

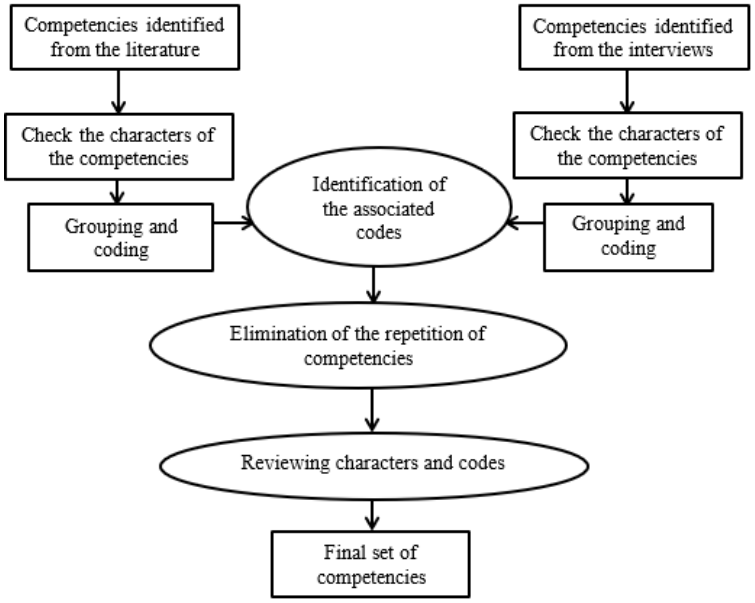

Figure 2: Sequential process of the qualitative thematic analysis

Table III: Detailed profile of the survey respondents

Profile	Variables	No. of Responses	Percentage
CIDA grade of contractors (X: Financial limit of the projects - LKR in million)	CS2 / CS1 (X > 1500)	04	10%
	C1 (1500 >= X > 600)	03	08%
	C2 (600 >= X > 300)	07	18%
	C3 (300 >= X > 150)	04	10%
	C4 (150 >= X > 50)	21	54%
Experience in the construction field	Less than 5 Years	01	03%
	5–10 Years	16	41%
	11–15 Years	10	26%
	16–20 Years	08	21%
	21–25 Years	04	10%
	More than 25 Years	00	00%
Job category	DME	21	54%
	AST	18	46%

handover, where a notable number of responses were received via post and email. The respondents were divided into two working categories based on their job titles, namely Director / Manager / Engineer (DME level) and Assistant engineer / Supervisor / Technical officer (AST level). The detailed profile of the survey respondents is shown in Table III. Notably, 54% of the survey participants were working at the DME level among the survey respondents, whereas the remaining 46% of them were from the AST level working categories. In particular, 97% of the survey respondents had at least five years of experience working in the construction industry, with the majority (41%) of them having 5-10 years of experience. Further, most of the respondents (54%) were from 'C4' graded contractors.

The Relative Importance Index (RII) approach was used to calculate the influence levels of the identified competencies on the efficiency, productivity and sustainability of road project operations, in line with the importance of quantitative approaches in interpreting the data in a scientific and numerical form highlighted by Dinh and Nguyen (2019). As suggested by earlier studies (Shahab and Audrius, 2018), Equation (1) was applied to determine RII values.

$$RII = \frac{\Sigma W}{A + N} \tag{1}$$

Here, W - assigned to each competency element by response ranges (1 – 'Extremely low', 2 – 'Low', 3 – 'Moderate', 4 – 'High', 5 – 'Extremely high'), A refers to the maximum weight given (A equals 5), and N indicates the total number of responses.

A greater RII value indicates considerable impacts on the effectiveness of construction operations from the corresponding element. The following RII value ranges were considered when determining the levels of effects of the competencies, and a minimum RII value of 0.7 was required to determine whether a particular competency was critical, as recommended by (Shanmuganathan *et al*. (2014). For each competency, the Coefficient of Variation (CV) values were determined in order to evaluate the validity and dependability of the findings. According to Statistics Canada (2020), a CV value of less than 0.3 ensures the reliability of the result for each factor. The CV value is defined as the ratio of standard deviation to RII values (Solly and Gezani, 2017). A CV value of less than 0.3 confirms the dependability of the outcome for each element, as per the criteria presented by Statistics Canada (2020). Notably, the ratio of standard deviation to RII values is used to establish the CV value (Solly and Gezani, 2017).

$RII >= 0.9$ = 'Very High'
$0.9 > RII >= 0.8$ = 'High'
$0.8 > RII >= 0.7$ = 'High – Moderate'
$0.7 > RII >= 0.6$ = 'Moderate'
$0.6 > RII >= 0.5$ = 'Moderate – Low'
$0.5 > RII >= 0.3$ = 'Low'
$0.3 > RII$ = 'Very Low'

The degree to which DME and AST level job categories agreed on the effects of construction supervision competencies in Sri Lankan road projects was assessed using Spearman's coefficient of rank correlation. Equation (2) was employed to determine this in accordance with suggestions made by recent studies, namely Kesavan *et al*. (2015) and Manoharan *et al*. (2020).

$$\rho = 1 - [6\frac{\Sigma D^2}{n(n^2 - 1)}] \tag{2}$$

Here,

ρ = refers to Spearman's coefficient of rank correlation
D = refers to the difference between the ranks of two variables
n = indicates the number of observations.

To determine the effects of the degree of agreement, the values of Spearman's coefficient of rank correlation were examined in the following ranges.

$\rho > 0 =$ Positive degree of agreement (Positive relationship)
$\rho = 0 =$ Neutral (No correlation)
$0 > \rho =$ Negative degree of agreement (Negative relationship)

E. Industry Consultative Discussions

A number of industry consultative discussions were held among construction professionals from various job categories in order to determine productive ways to improve the critical competency elements of construction supervisors. Notably, more than 25 academic and industry experts were involved in these sessions, who were directors, construction managers, team leaders, engineers, quantity surveyors and institutional experts. In the discussion sessions, problem-focused and action-oriented communication approaches were primarily employed. The outcomes of the discussion results confirmed the validity of the study findings.

III. Results and Discussion

The influence levels of competencies were established based on the RII values, as shown in Tables IV and Table V. The results show the extent to which each supervisory competency affects the efficiency, productivity and sustainability of operational flows in Sri Lankan road construction projects.

Based on their RII values, a set of 17 cognitive elements and 25 manual/transferable skills of construction supervisory competencies were determined to be critical. The knowledge of basic concepts of structures, performance evaluation techniques on labour skills, construction planning, site management and industrial research methods were found in the top five rankings when looking at the cognitive components of the construction supervisory competencies. The top five manual/transferable skills of construction supervisory workers in terms of rankings were labour management, communication, motivational skills, leadership and labour performance assessment. The majority of the competencies found in the top 10 rankings for each category were found to have considerable influences on the efficiency and productivity of construction activities in many other developing countries, including Australia (Hughes and Thorpe, 2014), Egypt (Montaser *et al*., 2018), India (Murari and Joshi, 2019) and Indonesia (Soekiman *et al*., 2011; Adi and Ni'am (Dinh and Nguyen, 2019).

Using Spearman's rank coefficient of correlation, the degree of agreement/disagreement between DME and AST level working staff regarding the construction supervisory competencies affecting the effectiveness of Sri Lankan road construction operations was found. The results demonstrate a positive degree of agreement/relationship of 83.8% between these two different working staff categories on the cognitive domains of construction supervisory workers. Regarding the skills/abilities of construction supervisory competencies, they agree (have a positive relationship) to a degree of 59.3%. The results demonstrate that there are few conceptual distinctions between DME and AST level working staff with regard to the manual/transferable skills of construction supervisors that influence the efficiency, productivity and sustainability of road project operations in Sri Lanka.

Through industry consultation discussions on the characteristics of those competencies and the current/future scopes of industry practices, the pertinent actions for enhancing the critical competencies of construction supervisors were determined. Effective skill development practices must therefore be implemented, with a specific focus on enhancing the construction supervisors' cognitive and manual skills/abilities in applying project management principles and techniques in construction operations, scheduling project tasks, adhering to quality assurance and control procedures and creating and maintaining a safe work environment. Such skill enhancement activities should further focus on core scientific and technological principles that have been significantly duplicated in a few studies from different countries, including Egypt (Montaser *et al*., 2018), Nigeria (Onyekachi, 2018), and Vietnam (Dinh and Nguyen, 2019). It is also worth noting that, while a few studies (Durdyev and Mbachu, 2011; Jarkas and Bitar, 2012; Jarkas *et al*., 2012; Montaser *et al*., 2018; Dinh and Nguyen, 2019) emphasised the importance of improving material handling competency traits of site supervisory workers, none of them presented what strategies should be considered. Further a few previous studies (Durdyev and Mbachu, 2011; Fernando *et al*., 2016) emphasised that site supervisors must have proper awareness and readiness to respond to concepts and applications related to water management, waste management, environmental management system, environmental sustainability, use of sustainable resources and other relevant green tools. Furthermore, past studies accentuate that site supervisors must have adequate cognitive and manual skills in areas such as safety foundation, safety policies, safety monitoring and control principles, safety culture, risk assessment, material and machinery movement, machinery/tool handling, biological/chemical hazards, mining safety, occupational health and disease, and first aid regulations.

Overall, by modernising institutional and industrial practices with a focus on enhancing the following competency elements of outcomes of construction supervisors, it is beneficial to address the other crucial competencies of construction supervisors listed in the top 10 rankings.

- Adhering to health and safety regulations
- Supervising road construction work with well-improved technical abilities
- Applying effective material management strategies
- Applying fundamental scientific and technological principles
- Utilising green practices while working on construction sites
- Identifying sustainable practices associated with restoration, rehabilitation and reconstruction for the urban development
- Identifying sustainable preservation and conservation ways for the community development
- Developing good practices in ensuring healthy work

Table IV: Impact levels of the cognitive elements of construction supervisors on the efficiency, productivity and sustainability of road construction operations

Cognitive Elements	Mean	RII	SD	CV	Ranking	Level of Impact
Basic concepts of structures	4.23	0.85	0.18	0.21	1	High
Performance evaluation techniques on labour skills	4.18	0.84	0.16	0.19	2	High
Construction planning	4.10	0.82	0.18	0.22	3	High
Site management	4.00	0.80	0.18	0.23	4	High
Industrial research methods	3.95	0.79	0.16	0.2	5	High-Moderate
English / Languages other than mother tongue	3.95	0.79	0.21	0.27	5	High-Moderate
Resource management	3.92	0.78	0.15	0.19	7	High-Moderate
Construction materials	3.90	0.78	0.12	0.15	8	High-Moderate
Basic labour laws and regulation	3.85	0.77	0.15	0.19	9	High-Moderate
Health and safety in construction	3.82	0.76	0.11	0.14	10	High-Moderate
Construction procedures and technology	3.82	0.76	0.12	0.16	10	High-Moderate
Quality assurance and control	3.77	0.75	0.12	0.16	12	High-Moderate
Material and equipment handling	3.72	0.74	0.11	0.15	13	High-Moderate
New technologies in construction	3.72	0.74	0.12	0.16	13	High-Moderate
Information and communication technology	3.72	0.74	0.10	0.14	13	High-Moderate
Financial knowledge	3.69	0.74	0.10	0.14	16	High-Moderate
Estimation	3.54	0.71	0.12	0.17	17	High-Moderate
Simple architecture	3.46	0.69	0.15	0.22	18	Moderate
Simple measurements	3.44	0.69	0.12	0.17	19	Moderate
Basic electricity	3.44	0.69	0.12	0.17	19	Moderate
Numeracy	3.38	0.68	0.12	0.18	21	Moderate
Environmental sustainability	3.36	0.67	0.12	0.18	22	Moderate
Waste management	3.33	0.67	0.15	0.22	23	Moderate
Environment and society	3.33	0.67	0.12	0.18	23	Moderate
Water management	3.23	0.65	0.15	0.23	25	Moderate

SD: Standard Deviation; CV: Coefficient of Variation; RII: Relative Important Index

Table V: Impact levels of the skills/abilities of construction supervisors on the efficiency, productivity and sustainability of road construction operations

Skills/Abilities	Mean	RII	SD	CV	Ranking	Level of Impact
Labour management	4.33	0.87	0.17	0.20	1	High
Communication	4.28	0.86	0.18	0.21	2	High
Motivational skills	4.28	0.86	0.18	0.21	2	High
Performance evaluation on labour skills	4.26	0.85	0.15	0.18	4	High
Leadership	4.26	0.85	0.13	0.15	4	High
Ability of conducting industrial researches	4.26	0.85	0.17	0.20	4	High
Decision making	4.23	0.85	0.15	0.18	7	High
Critical thinking	4.23	0.85	0.17	0.20	7	High
Optimisation	4.23	0.85	0.16	0.19	7	High
Problem solving	4.21	0.84	0.15	0.18	10	High
Analytical skills and abilities	4.21	0.84	0.12	0.14	10	High
Planning	4.15	0.83	0.14	0.17	12	High
Supervision of operations	4.13	0.83	0.16	0.19	13	High
Resource management	4.10	0.82	0.16	0.20	14	High
Efficient site management and coordination	4.08	0.82	0.15	0.18	15	High
Conflict resolution	4.08	0.82	0.13	0.16	15	High
Quality inspection	4.05	0.81	0.14	0.17	17	High
Innovative	4.03	0.81	0.15	0.19	18	High
Relationship with labour	3.95	0.79	0.12	0.15	19	High-Moderate
Time and priority management	3.95	0.79	0.13	0.16	19	High-Moderate
Impersonal skills	3.90	0.78	0.13	0.17	21	High-Moderate
Information and technology skills	3.82	0.76	0.12	0.16	22	High-Moderate
Ethical behaviour	3.79	0.76	0.12	0.16	23	High-Moderate
Technical skills and abilities	3.79	0.76	0.12	0.16	23	High-Moderate
Attendance	3.49	0.70	0.13	0.19	25	High-Moderate

SD: Standard Deviation; CV: Coefficient of Variation; RII: Relative Important Index

culture, social responsibility and environmental sustainability associated with heritage management

In addition to the above, the skills of the construction supervisors in implementing labour management techniques on construction sites, assessing labour productivity and measuring labour performance will enable them to identify practical ways and sustainable mechanisms to enhance the efficiency of project operations in the construction sector, as stated by Manoharan *et al*. (2022) through well-developed labour performance score system and grading scheme.

The standard deviations (SD) and coefficient of variations (CV) of the competencies ensure the validity and reliability of the results. As can be seen in Table IV and Table V, the CV values for every competency category were found to be less than 0.3. According to Statistics Canada (2020), these CV values ensure that the validity and dependability of the findings are at a satisfactory level for the current study's purposes. The degree of agreement/relationship between the perspectives of two distinct working categories as well as the discussion outcomes from the industry consultation all contributed to the credibility of these findings.

IV. Conclusions

The study has determined the essential competencies of construction supervisors that have severe influences on the efficiency, productivity and sustainability of construction operations in Sri Lankan road projects. The study first qualitatively identified the significant competency elements, then quantified how much they affect those specified characteristics of road construction operations, and it identified the next steps that the relevant authorities need to take to improve the practices currently used in construction supervision.

The study emphasises the urgent need to upgrade the training programmes currently provided to construction supervisors in Sri Lanka. The necessary workplace training elements and experimental exercises should be developed as per the key competencies determined in this study in order to apply constructive methods to construction supervision practices. The influence levels of the competencies shown in this study will be of great assistance to the training providers and skill development authorities for the purpose of making the necessary adjustments to the current training programmes. The study has also produced a few key competency elements of outcomes that carry relevant actions for enhancing the essential competencies of construction supervisors through practices in training and development. These results will be helpful for designing learning outcomes, learning content and delivery strategies for new training programmes based on industry needs. Overall, the study outcomes are expected to contribute to establishing sustainable practices associated with social/community development, environmental preservation, workplace culture and economy. As a result, a significant change can be expected in the fulfilment levels of workers' human needs, especially their physiological, safety, love and belonging, esteem and self-actualisation needs. In order to take the necessary steps to improve the reskilling and upskilling practices of the industry, construction firms, skill development agencies and training organisations in a developing country like Sri Lanka are expected to find the overall findings of the study to be of great assistance. Even though the study's focus is only on construction supervision techniques used in road construction projects in Sri Lanka, some of the findings might be tested in parallel situations in other emerging construction industries. Future studies are advised to focus more on improving procedures based on the essential competencies of construction supervisors presented in this study. These may further focus on assessing the existing frameworks and systems in developing countries and industries to form productive-based sustainable practices ensuring the generalisable and practical aspects related to training and development.

V. Acknowledgement

The authors sincerely thank the industry experts who provided active participation in the interviews, surveys and discussions of this study. Moreover, the authors wish to acknowledge the valuable support provided by the University of Peradeniya, Wayamba University of Sri Lanka (WUSL) and the Construction Industry Development Authority (CIDA) for this study.

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