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Factors Affecting Construction Labour Efficiency in Sri Lanka

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Abstract— The construction industry faces significant labor productivity problems, mostly in developing countries. It is well understood, that the construction industry deals with a variety of workforce issues daily and undergoes external and internal influences such as inflation, experience, and skill of labor, material availability in the market, and an unstable economy, indicating a growing focus on labor efficiency. This study aimed to identify and rank factors affecting construction labor efficiency in Sri Lanka. A questionnaire survey was formulated on factors found in the literature and distributed through email across construction companies throughout the country. The survey comprised results from 100 questionnaires sent, divided into 44 pre-selected factors, and 4 main groups: human/labor, management, technical and technological, and external. The relative importance index (RII) system was used to rank the factors. Surprisingly, the outcomes of the study revealed that the external factor category scored first, even though human/labor and management factors are the first two groups that come to mind when labor efficiency is the point of question. The following are the major five factors that have the highest influence on construction project labor efficiency in Sri Lanka. 1. experience and skill of labor; 2. on-site material availability 3. material availability in the market 4. political concerns; and 5. drawing error and design variation. These outcomes of the research are expected to assist project management teams in deriving an optimum amount of work from construction labor, keeping efficiency at optimum levels, and identifying early signs of declining efficiency.

Index Terms—Building Construction, Construction Industry, Labor efficiency, Productivity Improvement

1 INTRODUCTION

"Labor efficiency" is a significant issue in the construction sector and maintains a major position in efficient management even in any engineering company to improve its capacity and effectiveness in meeting the demand for construction products while supporting long-term national economic and social development goals. Whenever a product or service offered is not up-to-standard, it indicates that the construction industry faces challenges in improving productivity. Beyene [1] stated that since the construction industry deals with a variety of workforce issues daily, there is a growing focus on labor productivity. Many studies were conducted to measure labor efficiency in the construction sector in both developed and developing countries by the respective authors of Gundecha [2] in the USA, Enshassi et al. [3] in the Gaza Strip, Halwatura [4] in

Sri Lanka, Olomolaiye [5] et al. in Nigeria, and Makulsawatudom et al. in Thailand [6]. Most studies, however, gather information through site management staff rather than labor due to the difficulties of conducting surveys at working sites and their tight schedules. It was illustrated by Alinaitwe et al. [7] that there is a need to evaluate the absence of an agreed framework for measuring the impact of factors that lead to a decrease in worker productivity. Many definitions exist for the term “efficiency,” and it was referred to as an input-output comparison in the literature. Recently, efficiency has been described by Kazaz et al. [8] as "the dollar-based ratio of overall outputs to overall inputs.". However, it was retrofitted to the construction industry as a unit of labor output measurement for construction products and services by Makulsawatudom et al. [6]. Meanwhile, Alinaitwe et al. [7] verified that poor labor efficiency is one of the most influential problems, especially in developing countries. However, variation exists in factors affecting developed countries and developing countries. For example, in the case of a lack of material supply on-site, Polat et al. [9] reveal that in developing countries, contractors stock excess material while developed countries deliver materials just in time.

1.1 Problem Statement

Efficiency is one of the crucial factors in both developed and developing countries. Developing countries commonly face inflation, institutional weakness, unemployment, and chronic resource shortages, while developed countries focus on growth in the social economy and social welfare. Poor labor efficiency is a significant problem throughout the Sri Lankan construction industry, with limitations in terms of finance and time. Generally, conventional construction methods and a lack of proper equipment have been reasons for the Sri Lankan construction industry’s productivity to be lowered. However, these variables are determined not only by labor practices, but also by machinery, materials, building techniques, and site management, as discussed by Thomas and Sudhakumar [10]. However, it is difficult to conclude the real factors affecting the construction site efficiency in Sri Lanka due to insufficient details in the literature to study the efficiency in construction. However, identifying such factors is critical for improving the construction industry's quality and efficiency.

1.2 Aims and Objectives

The objective of this study is to identify and rank the key factors that influence construction labor productivity in Sri Lanka using the relative importance index (RII) method. As a result of the building industry's lack of competitiveness and difficulties in measuring it. The ultimate aim is to provide appropriate measures to improve construction labor productivity in Sri Lanka. Furthermore, the result could be used not only by local industry professionals (owners, CEOs, PMs, REs, QS, etc.) but also by international practitioners to achieve the project’s success. Even though budget overruns and yields of the project schedule are common for construction projects, especially companies inclined to take on large-scale projects with a lack of prior experience in the Sri Lankan construction industry, they will be able to gain awareness of the factors that influence labor productivity, and construction managers will be given guidance on how to effectively utilize the labor force.

1.3 Significance of labor productivity in the construction industry

The construction industry is affected by internal and external factors, with variations in impact over time. Labor efficiency has a significant influence on the construction industry since 30 - 50% of overall project costs consist of labor costs, as discussed by Alaghbari et al. [11]. Thus, improving labor productivity saves

considerable cost, time, and scope of work, as stated by Halwatura [4]. Zakeri et al. [12] verified that in several nations, the construction industry became a main growth factor, especially in developing countries, and evidence found that, in recent years, it has grown in scope and severity.

Moreover, Thomas & Sudhakumar [10] stated that due to the production of goods such as roads, buildings, and dams, the construction sector plays a critical role in the national economy. The gross domestic product (GDP) of the country also has a positive effect with improved productivity in the construction industry. In most countries, construction production accounts for one-half of total capital and 3% to 8% of GDP, as mentioned by Olomolaiye et al. [13]. Herbsman et al.[14] stated that despite the construction industry's enormous size and importance, productivity is one of the most contentious and poorly appreciated aspects of most countries' economies. According to Alwi[15] productivity increases directly proportional to the reduction of labor costs either to increase or decrease the overall project profit, transforming it into the success of the construction industry. Though many companies handover projects without collecting labor productivity data, clear identification of reasons for cost, time, and work overrun become extreme. Developing countries such as Uganda, Turkey, Thailand, and Yemen surveyed factors affecting construction labor productivity and found various major factors that were different from each other, according to [6]- [11]. It seems that economic political preferences and location have a huge influence over productivity. Halwatura[4] mentioned that few types of research have been conducted on Sri Lankan labor productivity through varied motivational strategies and revealed that the ten most severe factors that affect labor productivity such as medical care, over time, the opportunity of social interaction, employment protection, timely payment, employee canteen, proper guidance, accommodation, communication and love and belongingness. A vast area of factors had to be grouped for simplicity and better understanding. Though there were different groups consisting of factors affecting labor productivity, classification schemes of such groups are not yet being studied mentioned by Alaghbari et al..[11]. Ultimately, further work has to be conducted to investigate the factors that contribute to increased labor efficiency in developed countries since the economy of a country is directly affected by the efficiency of its construction sector.

2 MATERIALS AND METHODS

Five research types were illustrated by Fellows and Liu[16] survey, experiment, ethnographic research, action research, and case study, especially to collect construction industry research data. Experiments, surveys, and case studies are standard approaches for performing construction technology analysis. Conducting experiments on factors that affect labor productivity takes considerably a long time to give results with less control and therefore be expensive. In case study methods, results are not easy to deduct as different companies go through different problems. Finally, questionnaire surveys were considered to be appropriate due to the relative ease at which primary data could be obtained to meet the study's objectives.

Based on previous studies, factors influencing labor productivity were identified across the literature. A total of 88 factors were identified through past studies similar to developing countries like Sri Lanka and their economy and political preferences. Next, 44 factors were short-listed as being influential on the productivity of construction labor in Sri Lanka.

The factors were classified into four primary groups/categories: human/labor, management, technical & technological, and external. The questionnaire survey was created to quantify the impact of the identified factors on construction site labor productivity. The structured questionnaire consisted of two parts. The first part consists of the general information of the respondent (position, work experience, type of organization).

The second part consists of four tables representing a total of 44 factors. Each factor was measured using a four-point Likert scale comprising ratings from 1 to 4 where; 1 indicates the No effect and 4 indicates the Strong effect.

The target population included Engineers, Quantity surveyors, and Architectures, who are working in construction companies registered in ICTAD (now known as CIDA) and engage in formal construction works. The data collected were analyzed using the "Relative Important Index" (RII) (1) technique and this index was computed by the following equation [3], [17], [18].

$$RII = \frac{(4\times n4)+(3\times n3)+(2\times n2)+(1\times n1)}{A\times N} \times 100 \quad (1)$$

Where;
n1- number of respondents who answered "No effect"
n2- number of respondents who answered "Little effect"
n3- number of respondents who answered "Moderate effect";
n4- number of respondents who answered "Strong effect".
A is the highest weight=4,
N is the total number of respondents who answered for the ordinal scale

The RII approach is a pretty effective way of measuring employee satisfaction, making it a good match for this analysis [19]. Also, The RII technique will help policymakers allocate corporate capital by exposing basic elements that add the most to management and labor challenges[20]. Furthermore, this technique can be used to measure attitude for surveyed factors [21] The rank of each group is confirmed by evaluating the average value of the relative important index for all factors within each group. The data were sorted out and calculations were performed exploiting MS Excel spreadsheet software, where the results of each group were ranked and presented in this paper.

3 Results and Discussion

3.1 Ranking of human/labor factors

This category consisted of human/ labor factors (for both supervisors and labors) that impact construction labor productivity in Sri Lanka. Under this category (Table 1) predefined six factors were identified and ranked according to their effect on the efficiency of labor and supervisors in construction projects. With an RII of 100% "labor experience and skill" is ranked first in this group and also among all investigated 44 factors. In consequence, it is appraised as the most significant factor affecting construction labor productivity in Sri Lanka. Poor communication on site was ranked 2nd in the human/ labor factor group, with an RII of 89.29%, and 13th from place from overall 44 factors considered. With an RII of 78.57%, "Absenteeism" is ranked 3rd in this group and 26th overall. "Labor turnover", with an RII of 77.68%, is ranked fourth within this group and 27th overall. With RII of 68.75% and 66.96%, "Labor's age" and "Labor's education level" are ranked fifth and sixth at the end of this group and 39th and 37th places from all factors considered.

Table 1 Human/labor factors affecting construction labor productivity

Rank	Factors	RII(%)
1	Labor experience	100
2	Poor Communication	89.29
3	Absence to work	78.57
4	Labor Turnover	77.68
5	Labor age	68.75
6	Labor education level	66.96

3.2 Ranking Management Factors Group

The relative importance indices and ranks of the 16 factors classified under the management group are shown in Table 2. "Availability of materials at the site" ranked first with an RII of 99.11% in this group and second among all factors. With an RII of 91.96%, "lack of tools and equipment" is ranked second in this group and tenth place from overall factors considered. "Inadequate supervision" is ranked third with a RII of 91.07% within this group and 11th overall. However, with RII of 65.18% and 64.29%, factors "safety/accidents" and "poor planning" are ranked 15th and 16th within this group and 41th and 42th in terms of overall factors, respectively.

Table 2 Management factors affecting construction labor productivity

Rank	Factors	RII(%)
1	Availability of material on-site	99.11
2	lack of tools & equipment	91.96
3	Inadequate supervision	91.07
4	Duration of work	87.5
5	Inspection delay	86.61
6	Wages level for labors	83.93
7	Services provided to labors (Social Security/ insurance/ Medicare...)	82.14
8	Services provided on-site (water/electricity/WC.)	80.36
9	Daily hours of resting during the work (two hours)	74.11
10	Lack of incentives/ rewards	73.21
11	Working overtime (More than 4 hrs.)	72.32
12	Poor site layout	70.54
13	Unrealistic project schedule	69.94
14	Payment Delay	66.07
15	Safety/accidents	65.18
16	Poor planning	64.29

3.3 Ranking of Technical and Technological Factors

Table 3 shows the classified and ranked 12 factors according to their corresponding RII in the Technical /technological group. With an RII of 96.43%," drawing errors and design variations" is ranked first within the group and fifth among all factors. "Changes of order" is ranked second within this group and sixth among all factors with a RII of 95.54%. With an RII of 94.64%, "level of specification" is ranked third in this group and 7th overall. However, with RII of 67.86% and 46.79%, "factors specialized nature of the work

(masonry/plastering)" and project type (residential/industrial/infrastructure/investment...) are ranked 11th and 12th within the group, and 38th and 43th in terms of overall factors, respectively. "Project type" is ranked last among all factors affecting construction labor productivity in Sri Lanka.

Table 3 Technical and technological factors affecting construction labor productivity

Rank	Factors	RII(%)
1	Drawing error & design variation	96.43
2	Changes of order	95.54
3	Level of Specification	94.64
4	Building techniques and technology (traditional/ advanced/ panelized...)	93.75
5	Equipment required for work on the project (heavy, simple, or hi-tech)	90.18
6	Quality of material used	84.26
7	Project size	83.04
8	Type of structure (concrete/steel / load-bearing walls...)	81.25
9	Ease of preparation of material for work	79.46
10	Rework	76.79
11	Specialized Nature of the work (concrete, masonry, tiling, plastering...)	67.86
12	Type of project (residential/ infrastructure /investment/ industrial ...)	46.79

3.4 Ranking of external factors

The relative importance indices and ranks of the 10 factors classified under the external group are shown in Table 4. Three factors with Relative importance indices of 98.21%, 97.32%, and 92.86%, namely "material availability in the market", "political concerns" and "economic condition in the country (inflation)", are ranked first, second and third, respectively within this group. Moreover, these factors are ranked third, fourth, and ninth among all factors, respectively. However, with an RII of 71.43%, the factor" extreme weather conditions" is ranked 9th within this group and ranked 34th among all. In addition, with a RII of 75% "shortage of labor availability in the market" is ranked 8th within this group and ranked 30th among all factors influencing construction labor productivity. "Redundant labor availability in the market" is ranked last among affecting construction labor productivity in Sri Lanka.

3.5 Ranking groups of factors

The results in Table 5 demonstrate the ranking of 4 groups that affect construction labor productivity in Sri Lanka. Each group's average relative importance index is calculated and ranked. The external factor group is ranked first with the highest average RII value of 82.76%. This value is closely followed by the technical and technological group ranked second with an average RII value of 82.49%. Even though, "labor experience and skill" came in first in the overall ranking, surprisingly, the human/labor factor group is ranked third with an overall average RII value of 80.20%. Finally, with an average RII value of 78.64%, the management factor group ranked fourth and last.

Table 4 External factors affecting construction labor productivity

Rank	Factors	RII(%)
1	Material availability in the market	98.21
2	Political concerns	97.32
3	Economic condition	92.86
4	Ease of delivery (material and labor) to the site	88.39
5	Nature of project site (remote areas/highlands)	85.71
6	Social conditions in the country (poverty/illiteracy/migration)	84.82
7	The area of Project location (urban/rural/uninhabited areas)	75.89
8	Shortage of labor availability in the market	75
9	Extreme weather conditions (heavy rain, temperature)	71.43
10	Redundant of labor availability in the market	58.04

Table 5 Group factors along with RII value

Rank	Groups	RII(%)
1	External Factors	82.76
2	Technical and Technological Factors	82.49
3	Human/Labor factors	80.2
4	Management factors	78.64

3.6 The top ten factors affecting construction labor productivity in Sri Lanka

The apprehended impacts of the overall 44 factors surveyed are summarized in Table 6. As shown the factors were ranked corresponding to their Relative importance indices. Among all factors considered for the research, labor experience and skills that fell under the human/labor group, were rated first by the industry professionals who participated in the survey, stipulating that it is the top significant factor affecting Sri Lankan construction labor productivity. This result is supported by the findings reported by Shree Raja Gopal [22]with the skill of labor listed first in its significance to labor productivity. This outcome is also reinforced by results from Tahir et al.[23], Mahamid et al. [24], and Alaghbari et al. [11]. Research conducted by Jarkas & Bitar [25] reveals that unskilled workers are characterized by low output and high input. Further, those outputs are often rejected either entirely or partly by the supervisor team, causing rework, rectifications, or repairs. In converse, experienced workers are known for their good analytical ability, realistic problem-solving strategies, and high technological and motor capabilities, both of which contribute to improved efficiency, reduced labor costs, and better-quality outputs. However, in research conducted in Uganda by Alinaitwe [7], Singapore by Lim et al. [18], and Kuwait by Jarkas & Bitar [25], skilled labor is listed as second place and labeled as, “lack of skills of workers “, “difficulty in labor recruitment “and “skill of labor”, respectively. In the Sri Lankan context, construction labor consists of both skilled and unskilled workers but due to a lack of government institutes to educate, and train labor, it takes years of apprentices for unskilled labor to become skilled and experienced workers. The time taken for this transformation holds up the progress of labor productivity. Further, Labour experience and skill a recognized factors in most labor-intensive industries where higher productivity is attained.

Furthermore, the results of the study revealed that "availability of materials in site" under the management factor group ranked second place among overall factors. While the significance of this factor to labor productivity is obvious, it is also known as one of the major factors influencing construction labor productivity in Thailand, Indonesia, Malaysia, Nigeria, and Iran respectively revealed by the authors, Makulsawatudom et [6], Kaming et al. [26], Kadir et al. [27] Olomolaiye et al. [5] and Zakeri et al. [12]. A study conducted by Thomas et al. stated that ineffective material management leads to insufficient use of labor ([28]. Research performed in Iran by Zakeri et al. reveals seven factors cause the non-availability of material on site such as waste due to kadi negligence/sabotage, on-site transport difficulties, improper material handling, improper material usage to specification, poor planning, improper material delivery to site and excessive documentation for material requisition [12]. Project management should be responsible for procuring materials from suitable suppliers and store according to the work schedule ahead. The former factor raised its importance because project activities are often interdependent and each activity suffers from various disruptions in the construction phase i.e., the need for scaffolding/ formwork.

Meanwhile, the "availability of materials in the market" categorized under the external factors group took the third rank in the study. However, this factor is open to doubt since Sri Lanka is enriched with construction material manufacturing plants and has less amount of imported construction materials. This was probably caused due to the time when the research survey was conducted (2020 to 2021) when covid-19 virus epidemic stopped material importation and manufacturing plants to a standstill.

The fourth ranking factor affecting construction labor productivity in Sri Lanka, "political concern" takes place. Changes in political parties spread influence over the government projects and due to corruption and lack of financial support passed by the treasurer either cause projects to be postponed or terminated. These issues directly affect the interim payments to be received and cause payment delays on labor.

Table 6 (a) Overall ranking of factors

Rank	Factor	RII (%)	Group
1	Labor experience	100	Human factors
2	Availability of material on-site	99.11	Management factors
3	Material availability in the market	98.21	External factors
4	Political concerns	97.32	External factors
5	Drawing error & design variation	96.43	Technical factors
6	Changes of order	95.54	Technical factors
7	Level of Specification	94.64	Technical factors

Table 6 (b) Overall ranking of factors

8	Building techniques and technology (traditional/ advanced/ panelized...)	93.75	Technical factors
9	Economic condition	92.86	External factors

10	lack of tools & equipment	91.96	Management factors
11	Inadequate supervision	91.07	Management factors
12	Equipment required for work on the project (heavy, simple, or hi-tech)	90.18	Technical factors
13	Poor Communication	89.29	Human factors
14	Ease of delivery (material and labor) to the site	88.39	External factors
15	Duration of work	87.5	Management factors
16	Inspection delay	86.61	Management factors
17	Nature of project site (remote areas/highlands)	85.71	External factors
18	Social conditions in the country (poverty/illiteracy/migration)	84.82	External factors
19	Quality of material used	84.26	Technical factors
20	Wages level for labors	83.93	Management factors
21	Project size	83.04	Technical factors
22	Services provided to labors (Social Security/ insurance/ Medicare...)	82.14	Management factors
23	Type of structure (concrete/steel / load-bearing walls...)	81.25	Technical factors
24	Services provided on-site (water/electricity/WC.)	80.36	Management factors
25	Ease of preparation of material for work	79.46	Technical factors
26	Absence to work	78.57	Human factors
27	Labor Turnover	77.68	Human factors
28	Rework	76.79	Technical factors
29	The area of Project location (urban/rural/uninhabited areas)	75.89	External factors
30	Shortage of labor availability in the market	75	External factors
31	Daily hours of resting during the work (two hours)	74.11	Management factors
32	Lack of incentives/ rewards	73.21	Management factors
33	Working overtime (More than 4 hrs.)	72.32	Management factors
34	Extreme weather conditions (heavy rain, temperature)	71.43	External factors
35	Poor site layout	70.54	Management factors

Table 6 (c) Overall ranking of factors

36	Unrealistic project schedule	69.64	Management factors
37	Labor age	68.75	Human factors

38	Specialized Nature of the work (concrete, masonry, tiling, plastering...)	67.86	Technical factors
39	Labor education level	66.96	Human factors
40	Payment Delay	66.07	Management factors
41	Safety/accidents	65.18	Management factors
42	Poor planning	64.29	Management factors
43	Redundant of labor availability in the market	58.04	External factors
44	Type of project (residential/ infrastructure /investment/ industrial ..)	46.79	Technical factors

The fifth and sixth-ranked factors among the others in the present study are “errors in drawings and design variations” and “changes of order” respectively. Both factors combined as one and revealed namely, “the extent of variation/change orders during execution” which was found by Jarkas & Bitar and ranked second in the case of Kuwait [25]. Incomplete drawing ranked second by Makulsawatudom et al. in the study performed in Thailand [6]. Research done in Iran by Zakeri et al. stated four commonly reported problems causing design, drawing, and change orders such as errors in design, contradiction in architectural, structural, mechanical, and electrical drawings, contractor specifications conflict with drawing specifications, and excessive revision and change orders [12]. Thomas & Napolitan calculated that there is a 30% efficiency loss when work changes are being performed [29]. Former factors occur due to limited time and budget provided to the designer by the client, to expedite the bidding process. Because of that, in the construction phase drawings are often found either unclear, incomplete, or non-conformance with other drawings. The provision of additional time for adjustments of resources and manpower can be used to alter this effect.

Similar to the fifth and sixth ranking, the seventh rank was occupied by “level of project specifications”. The relevance of this factor to labor productivity is apparent, and it was also listed as one of the factors impacting construction productivity in the United Kingdom, Thailand, and Uganda [6], [7], [11], [30]. Former factors became the most significant factor affecting construction labor productivity in Kuwait in a study done in 2012 by Jarkas & Bitar [25] which stated that this factor stipulates greater issues with the quality of designers’ outputs in Kuwait. Low levels of specifications provided in the construction phase of a project cause sequential interruptions and /or disruptions in the work schedule and it requires continuous requests for clarifications. Further, it may lead to rework on sites after the revisions of design documents received where low productivity of labor is acquired. The main reason is probably the lack of time available for designers to finalize the specifications. Similar to the above two factors discussed, additional time and manpower provision to the designer can resolve this issue.

The factor that obtained the eighth rank from the present study in the context of Sri Lanka is “building techniques and technology” which falls under the technical and technological category. In general, either traditional or advanced building techniques and technologies are used. However, labor productivity increases with advanced building techniques rather than using traditional techniques and technologies. i.e., the use of vibrators for curing rather than traditional curing by hand. Advanced technologies are most probably time-saving, easy to handle, and increase labor output rather than traditional techniques.

The ninth-ranked factor, “country’s economic condition”, is supported by the study conducted in Yemen

by Alaghbari et al. [11] reveals that poor economic conditions influence the labor productivity of most unskilled construction labors who try to earn extra income to cover their expenses. Especially labor paid by daily wages due to their lack of experience. So, the former factor is interrelated with labor experience and skills which is favored by Jarkas & Bitar [25] revealing that in the construction phase, the lack of experience and skill is the exact opposite of development. The economy of the country extensively varies due to major incidents like inflation in the stock market and recent incidents such as covid-19 virus pandemic which crucially affects globally. They spread influence over Gross Domestic Product value up to labor cost. Since a greater amount of the Sri Lankan economy consists of the construction industry, it is doubtful to interpret that the economy of the country has an impact on construction labor productivity.

The factor that took the tenth place out of overall factors in this study is "lack of tools and equipment". The same factor ranked first place in the study performed on Egypt by Gerges et al. [31]and fourth place in research conducted in the USA by Gundecha [2]. Further in Uganda study done by Alinaitwe et al. [7] ranked the former factor in fifth place on overall factors. From every material transportation to the entire construction process heavily relies on tools and equipment. For instance, truck mixers and concrete pumps are required to perform concrete transportation and placing operations, scaffolding is essential to continue construction vertically. Disruption of equipment or tools guides to slow down or standstill operations causing grave material-handling problems. Moreover, Makulsawatudom stated that ignorance of maintenance programs and incompetent project managers who overestimate the capacity of equipment affect labor productivity in Thailand[6]. Ultimately, without proper tools and equipment to perform activities, projects will be delayed resulting in cost and time overrun and decreasing construction site labor productivity. Nevertheless, the relative importance indices obtained of technological and technical factors and the human/ labor factor category took second and third place, while the management factor category took fourth place. It is surprising as the third-ranked category includes the factor ranking first in overall factors that affect construction labor productivity in Sri Lanka. Moreover, the recent breakthrough of covid-19 virus epidemic in 2020 caused the national economy to fail and indirectly impacted the construction industry to change its factors. This is understandable by the emergence of external factors that hit the third, and fourth places from the overall factors considered in the present study.

4 Conclusion

This study has identified and, based on the quantified relative importance indices, determined the influence ranks of 44 factors affecting construction labor productivity in Sri Lanka. The factors obtained were, in addition, classified under the following primary groups: 1. human/labor, 2. management, 3. technical and technological, and 4. External. Questionnaires were sent through email, based on the factors identified, and a total of 100 questionnaires were sent and 27 valid responses were collected back. The survey data was analyzed, and the variables were ranked according to their relative importance index. The most significant factors affecting construction labor productivity of construction projects in Sri Lanka are; 1. Labor's experience and skills, 2. Availability of material on site, 3. Availability of material in the market, 4. Political concerns, 5. Drawing error and design variations, 6. Change of orders, 7. Level of specification, 8. Building techniques and technologies, 9. Economic condition, and 10. Lack of tools and equipment. The results revealed that these 10 factors ranked between RII = 100% and RII = 91.96% are the major factors affecting labor productivity in Sri Lanka. However, the external group is ranked first of all groups. On the other hand,

out of the top ten factors, four were from the technical and technological group, two from the management group, and only one from the human/labor group. According to the obtained results, it is clear that external factors unexpectedly have a stronger effect than human/labor and management factors which are the first two groups that come into mind when labor productivity is the point of question. External factors have perceived its importance over the construction labor productivity, especially in developing countries. In the context of Sri Lanka, the fact that human/labor factors ranked third and external factors first is understandable due to the unexpected disasters that happened during the time of the study conducted. In the beginning, a tragic terrorist bombing caused a rise in the security of the country, and further, the breakthrough of covid-19 virus shut down the workforce of the country for a long time placing the national economy in a weakened state. Moreover, sudden changes in rules on importing goods and curfews over the country affect the economy along with political changes and material availability in markets for the construction industry. The findings are believed to contribute to the present construction industry in Sri Lanka by informing the parties of the positive and negative impacts of the factors. It was expected to save time and costs of construction projects and to mitigate delays and stalled projects in the country. Ultimately, based on the results obtained, the following recommendations are made to enhance construction labor productivity in the country;

1) Training/ education opportunities especially for labor should be provided and promoted in Sri Lanka. Where, construction supervisors, technical officers, and other professionals have adequate learning facilities than laborers. The current training available for labor is inadequate and the government should partner with industry to provide facilities and apprenticeship programs where labor can develop skills and experience required to industry standards. Further, contractors can also offer assistance and implement training sessions for their craftsmen. Motivational or financial reward schemes, similar to those used by top employees of the year, can be enforced to improve labor competitiveness and thereby increase productivity.

2) Project management should address materials available on-site at an early stage and handle them effectively, to minimize time, and cost overruns and prevent labor from being idled which affects not only labor productivity but the whole construction process.

3) The government should take proactive action to control material's price and availability where in case of influencing incidents like covid-19 epidemic breakthrough. This sometimes encourages potential major suppliers to create an artificial shortage of material on the market for profit causing projects to experience delays.

4) Sri Lanka is a politically active country and its influence spread over various industries. For example, with the change of governments, rules and regulations may change either positive or negative sides. It was practically demonstrated by strikes called by political parties. Further, politicians are involved in corrupting tendering procedures for commissions and unlawfully employing incompetent people, especially for state-owned companies. Therefore, the government needs to provide a set of rules and regulations to cease such illegal involvements in the construction industry.

5) Clients should always allocate adequate time for designs and drawings in the design phase of the project even though the designer's fee typically ranges between 2 to 5% of the project's construction cost because the decisions made during the former phase have a maximum impact on construction cost. On the other hand, it becomes much more expensive when it comes to design or drawing errors in the construction phase. It is also advised that the designing team should be quite experienced to avoid revised drawings.

6) Procurement methods that allow the participation of contractor parties during the design stage of projects (such as design/build (DB), procurement and construction (EPC), or turnkey), should be considered since the construction phase can benefit from the previous construction experience of contractors at an early

stage of the design phase. Moreover, minimizing change orders will reduce the time and cost overrun of projects contributing significantly to productivity.

7) Unclear or outdated specifications lead to disruptions at the site and it is the designer's responsibility to provide adequate specifications along with drawings without delaying the construction process. Designers should be experienced and aware of possible errors and should be capable of identifying and providing better solutions. Changes to design sketches and specs can be avoided by recruiting experienced design contractors who have completed similar projects.

8) Advanced building technologies should be promoted to save time and increase labor productivity at the same time.

9) The economy of the country depends upon various events occurring over time and its impact is unavoidable. For example; covid-19 virus epidemic. However, it emphasizes the significance of rules and regulations of the country to stabilize its economy in such incidents. Even though the control is out of hand, policymakers should introduce policies to stabilize the economy in such scenarios.

10) Necessary tools and equipment should be available for the work activity by the site management team and along with that maintenance, calibrations, and equipment training programs must be conducted.

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