Workmanship Performance Benchmarking Model: The Role of Assessment Factors

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Abstract– ***Several studies have been conducted on factors contributing to poor workmanship on construction projects and possible measures to mitigate the problem. Lack of experience, communication, language barrier, construction equipment, poor weather, and limited time and costs are among the most notable factors contributing to poor workmanship. Unfortunately, the factors required for workmanship performance assessment at both the project level and the organizational level are yet to be identified. As such, the objective of the study is to develop factors for an integrated benchmarking framework to measure the workmanship performance of building projects to ensure construction quality. The study undertakes a comprehensive assessment of the literature and administered a survey to the building and construction professionals. The study outcome novel factors for workmanship performance assessment. This research is expected to assist with contract tendering, evaluation, quality control and workmanship performance standard development and assessment tools for the construction industry in Caribbean Countries and Latin Americas.***

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I. INTRODUCTION

The impact of defective workmanship on the performance of the building systems has been described as the major problem facing the construction industry [1] [2]. The most prominent workmanship problem facing most developing countries is defect in buildings as well as inferior quality materials [3] [2]. The authors further state that workmanship is governed by many factors aggregating together and contributing to the performance of the building. The evidence of poor workmanship in building construction includes incorrect proportioning, drying cracks, workmanship defects, decreasing bond strength, and poor material handling [3] [2]. In general, defects occur as a result of lack of knowledge, lack of information, and lack of motivation. These defects can be mitigated with the integration of an International Standard Organization (ISO) standard related quality management technique such as Total Quality Management (TQM) into the construction project. Nevertheless, the majority of human errors on construction projects were due to forgiveness and carelessness [4]; carelessness was the most significant cause of defect [5]. Additionally, 30 % of human errors were due to inadequate knowledge of the construction management and quality policy, quality-related training, product and service design, supplier quality management, process management, operating procedures, quality data, reporting, and the employer-employee relationship [5]. However, even though there are some existing quality assessment frameworks such as TQM, Six Sigma, Safety Management System (SMS), Quality Management System (QMS), ISO, the desirable aggregating factors for workmanship performance assessment is yet to be identified. Hence the aim of the study to develop workmanship performance factors to be aggregated for workmanship performance assessment in the construction industry.

II. WORKMANSHIP PERFORMANCE ASSESSMENT AND EXISTING QUALITY TECHNIQUES

The empirical relationship between existing quality techniques and workmanship performance assessment has not been established. Numerous performance assessment factors were developed and used with the existing quality assessment techniques such as TQM, SMS, Six Sigma, and QMS [6] [7] [8]. These existing assessment factors are considered necessary but insufficient for the current workmanship performance assessment. However, despite research efforts, it is still challenging to establish a comprehensive list of Critical Success factors (CSF) for the successful implementation of the TQM approach in the construction industry [9]. According to the authors, the term critical success factor implies the elements that are vital and significant to the success of the construction organisation and projects. The diverse and conflicting objectives of the stakeholders make it difficult to agree on a standard list of CSF for TQM implementation in the construction industry. It is, therefore, suggested that Critical Success Factors be further assessed to identify a suitable practice to achieve success in TQM implementation [6] [8] [10]. Additionally, several studies have been conducted since 1960 to identify the CSF considered most essential and crucial for TQM implementation [7] [8] [10]. Furthermore, in order to understand the roles of CSFs in the construction industry, the present study developed a new set of workmanship performance assessment factors.

III. METHODOLOGY

To achieve the research objectives, the main and sub-factors relevant to the workmanship performance assessment framework were developed through a survey method. The primary purpose of the survey was to assist in identifying the essential critical success factors that could facilitate effective quality workmanship management in the construction industry. Therefore, a semi-structured questionnaire was designed and comprised two key sections: demographic information and ranking of factors related to organisation and project workmanship performance assessment. The purpose of this ranking was to identify a set of main factors for workmanship performance assessment at both organisational and project levels. The ranking was based on a scale of 1 (very important) to 21 (least important) for organisational related factors and 1 (very important) to 23 (least important) for project-related factors. The data were collected from building and construction professionals in Trinidad and Tobago. Out of the 320 questionnaires administered to the professionals, 190 were returned, 95 % were usable.

VI. DATA ANALYSIS AND DISCUSSION

A. Demographic Information of Research Participants

The demographic information summarised in Fig. 1 suggests that the survey covered the population targeted for the research. The questions covered in this section include the position in the organisation, age group, and length of work in the organisation. The results show that the participants selected for this study were reliable. The response to the first question as shown in Fig. 1 indicates that the majority of the research participants were contractors (33 %). This signifies that the participants possessed the technical knowledge and experience required for this study. Moreover, 66 % of the research participants were within the 29-39 and 40-49 age groups as shown in Fig. 2. Additionally, 55 % of respondents have more than six (6) years of experience in construction workmanship related activities, followed by participants with 4-5 years' experience (30 %) (Fig. 3). These results further show that 90 % of the research participants have the experience, knowledge, and technicality required for the study. Hence, the main and sub-factors identified for workmanship performance assessment of construction projects are credible and reliable.

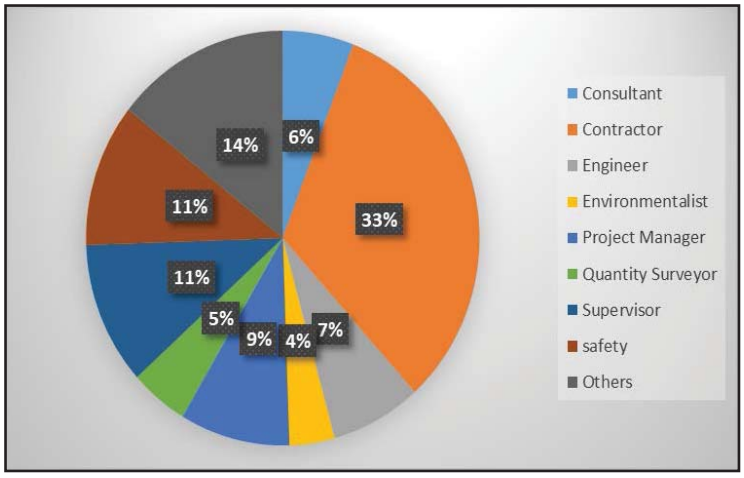

Fig. 1 Distribution of respondent by professional category

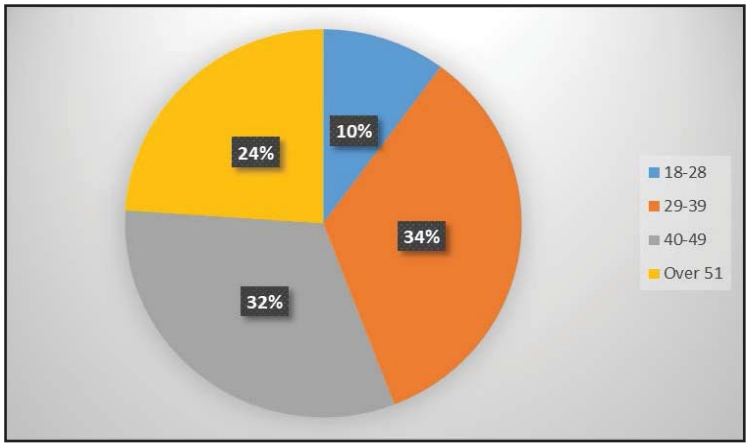

Fig. 2 Distribution of respondent by age category

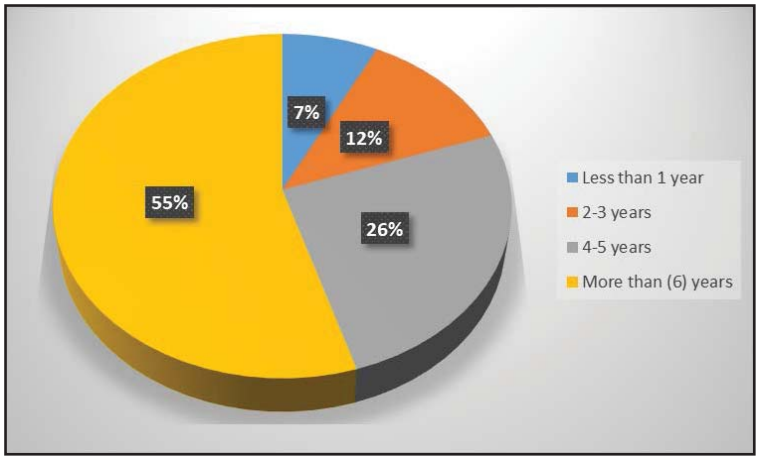

Fig. 3 Distribution of Respondent by Experience Category

B. Workmanship Main Factor Analysis

The data collected from the questionnaires were analysed according to the Mean Ranking (MR) and Relative Important (RI) index. The RI was computed for each main factor using the Mean Ranking formula adopted by Ng et al. [11]. The MR was then used to determine the RI for each main Workmanship Performance Assessment (WPA) factors. As shown in Fig.4, Top Management Commitment was rated as the most important main factor at the organisational level. Additionally, top management commitment is described as the fundamental factor to TQM implementation at both organisational and project levels [7] [12] [13]. Also, according to Fig.4, respondents indicated that Safety Leadership, Performance Measurement System, Continuous Improvement, Quality Culture, Customer Satisfaction, Safety Training, Process Planning, Employee Empowerment, Information and Communication, Strategic Quality Management,

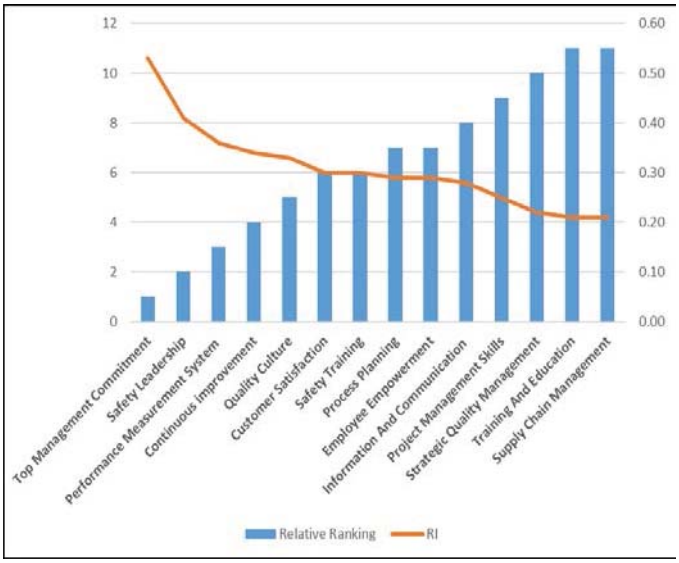

Fig.4 Organizational workmanship main factor ranking

Training and Education, and Supply Chain Management were the main factors and most important for workmanship performance assessment at the organisational level. These main factors recorded a higher ranking compared to other main factors assessed based on the RI index values. These findings confirmed the identified main factors as the most appropriate CSF for organisational workmanship performance assessment. In contrast, the Quality Initiative to Business was considered the least important to organisational workmanship performance assessment, followed by a Quality Initiative to Customer, Employee, and Supplier. Also considered least important include "Project Selection, Environmental and Society Impact. The figures ranked the performance of the selected main factors based on their RI performance to organisation workmanship (Fig. 4) and project workmanship (Fig. 5). Hence, the results depicted in Fig. 4 suggests a new set of main factors for organisational workmanship performance assessment.

On the project-related WPA, project nature, economic investment, customer satisfaction, performance measurement system, competency profile, process planning, and top management commitment were ranked the most important main factors for project workmanship performance assessment and considered essential for project implementation (Fig. 5). Furthermore, since project implementation required using the right skills, standard, and management to execute factors such as performance measurement system, competency profile, process planning, top management commitment, operational control, risk management, strategic quality management, and safety climate were also considered to be important main factors for project workmanship performance assessment.

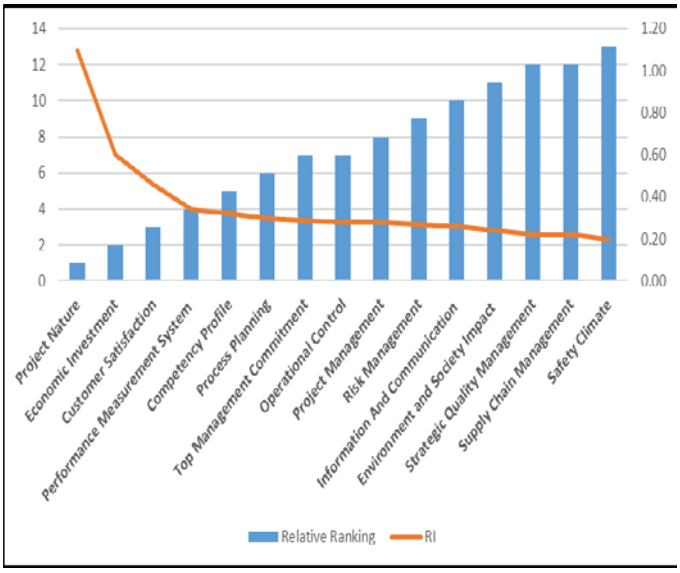

Fig. 5 Project workmanship main factor ranking

However, some factors were ranked least important to project workmanship performance such as individual involvement, continuous improvement, and quality culture (Fig. 5). These factors were ranked least important because the participants believed they were less relevant to project workmanship performance. The participants with experience in building and construction activities, however, considered these factors more relevant to organisational workmanship performance than project workmanship performance. Overall, the findings have established a set of new main factors for project workmanship performance assessment. Moreover, the most crucial and essential CSF's for both project and organisational workmanship performance assessment were identified, when workmanship performance assessment factors in Figures 4 and 5 were combined and ranked in Fig.6.

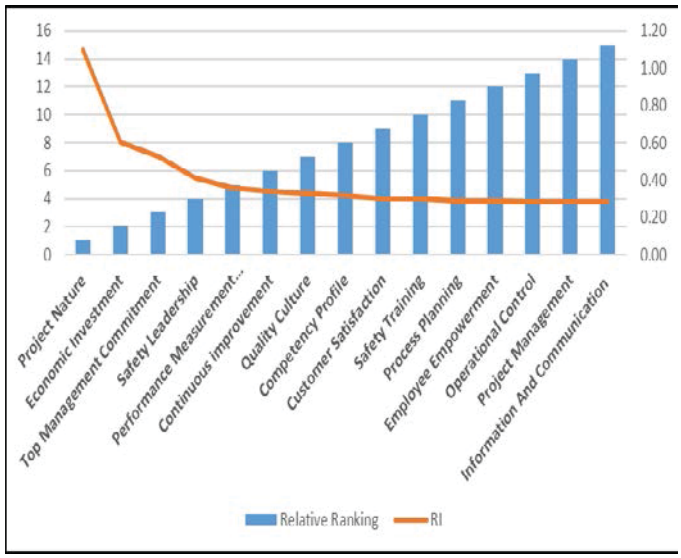

Fig.6 Combined ranking workmanship performance assessment factors

C. Sub-Factor Analysis

The data collected from the subfactor questionnaires were analysed according to the Mean Score (MS) and RI [11]. The RI was computed for each subfactor. The MS was then used to determine the RI for each Workmanship Performance Assessment (WPA) sub-factors (Table 1). Under the Organisation Sub-Factor RI index (Table 1), Top management commitment to quality; Allocate adequate time and resources for quality improvement, Top management learning from problems, Designation of safety responsibilities to trained personnel, and Adequate and timely supply of PPE were rated and ranked among the most important subfactors to be assessed for organisational workmanship performance. Besides, there was no significant difference in the sub-factors RI weight performance. Similar results were observed under project RI index ranking (Table 1). In both cases, 95 % of the subfactors assessed recorded RI above 0.015 performance benchmark. This signifies that the subfactors are important and relevant for workmanship performance assessment at both project and organisational levels.

Table 1 Organisation Sub-Factor Relative Importance Index

Sub factor Notation	RI	Sub-factor Notation	RI
TMC1.1	0.018	RM1.1	0.019
TMC1.2	0.021	RM1.2	0.020
TMC1.3	0.019	RM1.3	0.018
TMC1.4	0.013	OC2.1	0.018
TMC1.5	0.016	OC2.2	0.019
SL2.1	0.019	OC2.3	0.018
SL2.2	0.018	OC2.4	0.019
SL2.3	0.019	OC2.5	0.018
SL2.4	0.014	TMC3.1	0.019
SL2.5	0.016	TMC3.2	0.016
PP3.1	0.016	TMC3.3	0.019
PP3.2	0.019	TMC3.4	0.019
SQM4.1	0.018	TMC3.5	0.019
SQM4.2	0.020	CP4.1	0.018
SQM4.3	0.019	CP4.2	0.018
ETE5.1	0.016	CP4.3	0.017
ETE5.2	0.020	CP4.4	0.017
ETE5.3	0.019	CP4.5	0.018
ETE5.4	0.019	SC5.1	0.020
ETE5.5	0.014	SC5.2	0.020
ETE5.6	0.010	SC5.3	0.020
SCM6.1	0.017	SC5.4	0.018
SCM6.2	0.021	SC5.5	0.019
SCM6.3	0.013	PM6.1	0.019
SCM6.4	0.014	PM6.2	0.019
CS7.1	0.020	PM6.3	0.019
CS7.2	0.019	PM6.4	0.019
CS7.3	0.020	PM6.5	0.019
CS7.4	0.020	PN7.1	0.015
IC8.1	0.018	PN7.2	0.018
IC8.2	0.018	PN7.3	0.017
IC8.3	0.020	EI8.1	0.013
IC8.4	0.018	EI8.2	0.017
IC8.5	0.018	CS9.1	0.021
PMS9.1	0.020	CS9.2	0.019
PMS9.2	0.015	CS9.3	0.019
PMS9.3	0.020	CS9.4	0.020
		PM10.1	0.018

In comparing the importance of subfactors to workmanship performance assessment (Table 1) RI index range between 0.015 and 0.020, suggesting the existence of a close-range level of importance among the subfactors assessed. However, some lesser performances were recorded under Employee Training and Education (ETE), Top Management Commitment (TMC), Economic Investment (EI), and Supply Chain Management (SCM) sub-factors. Overall, the majority of the subfactors are considered relevant and appropriate for workmanship performance assessment.

V. INTEGRATED WORKMANSHIP PERFORMANCE BENCHMARKING FRAMEWORK

The workmanship performance factors were further assessed to develop an integrated framework (Fig. 7). This framework development involves blending the common factors from TQM, Six Sigma, and SMS frameworks. Moreover, according to Figs. 2 and 3, the leading main factors recorded lower-ranking numbers with higher relative important index. The factors identified when both project and organizational main factors were combined include top management commitment, quality culture, safety leadership, performance management system, project nature, employee empowerment, and involvement. Top management commitment was ranked first and most important because leadership commitment is considered the main determinant of TQM practice performance [11] [17]. Moreover, top management commitment is described by some researchers as a fundamental factor in TQM implementation in organisations and projects [13] [10]. The authors stated that top management commitment involves leadership participation, monitoring, resource allocation, and recognition.

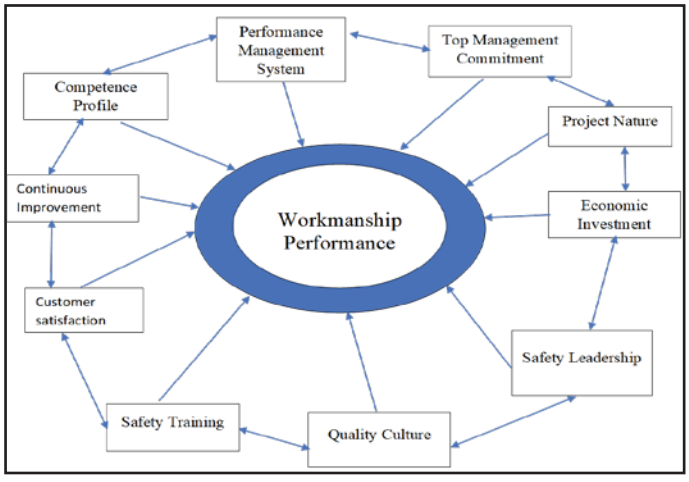

Fig. 7 Integrated Framework of Workmanship Performance Assessment

Some researchers have conducted studies on the relationship between organisational culture and leadership style and found that organisational culture is strongly influenced by leadership style and subsequently has a significant impact on outcomes, organisational commitments, expectations, subordinate performance, and job satisfaction [14]. Other researchers stressed that organisations should work towards improving the process to ensure the improvement of the final product [10]. Likewise, the organisation and supply chain process should be directed to improve customer focus and quality performance [15]. The process must be strategically planned and managed to ensure long-term sustainability, competitiveness, and customer satisfaction. Customer satisfaction is one of the key elements in the implementation of TQM within an organisation and project. Moreover, customer satisfaction is directly linked to company success and quality improvement [16]. As such, by addressing and understanding client or customer needs and expectations, anticipating their evolving interests, and establishing a communication network with clients, an organisation can overcome its competitors and increase market share. Thereby establishes a combined new set of workmanship factors for an Integrated Workmanship Performance Benchmarking Framework in relation to both project and organization workmanship performance.

V. CONCLUSION AND RECOMMENDATION

The study identified relevant WPA factors and analysed the importance of these factors leading to the development of a more comprehensive benchmarking framework for assessing the workmanship performance of projects and organizations in the construction industry. Thus, provides an integrated benchmarking approach that can assess and appraise the construction company workmanship performance at both organization and project levels. This approach combined the methodological framework and critical success factors from TQM, SMS, and Six Sigma techniques. Consequently, the integrated workmanship benchmarking framework as developed in this study through the identified aggregating factors involving main and sub-factors could be applied at the tendering stage for project evaluation and award. Also, it can assist contractors to make informed decisions on construction workmanship performance. In addition, potential defects and safety hazards could be identified at an early stage of the construction projects to ensure necessary measures were taken to minimize financial loss and failure. Moreover, it is important to further investigate the practical application of these factors and their impacts on workmanship performance in selected construction projects and organizations. This aspect of the study is currently being investigated through the practical application of the integrated benchmarking framework to selected building and construction projects in Trinidad and Tobago. The projects being assessed in terms of workmanship performance include: Guardian life building roof waterproofing and renovation project and Port Authority

Marine Pile Installation for inter-Island ferries in Trinidad and Tobago.

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