DETERMINANTS OF WORKMANSHIP: DEFINING QUALITY IN CONSTRUCTION INDUSTRY

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Quality is one of the key objectives of any project. To achieve good quality, workmanship is an important factor to consider. However, very few studies have explored the causes of poor workmanship in the past. Hence, this research aims to identify the determinants of workmanship affecting the quality of the construction work at the sites. To achieve this, first, the literature review was carried out, and 10 determinants were identified. Subsequently, key determinants were determined through two independent investigations covering industry professionals (top-down approach) using the Delphi technique, and the construction workers (bottom-up approach) using a questionnaire survey technique. The results found five key determinants; and, reveal the differences in the opinion of the construction workers from the industry professionals. The results will help the training providers to train the workers specifically on the improvement of the identified determinants of workmanship to resolve the problem of poor quality of construction work.

Keywords: workers, Delphi technique, quality, training, workmanship

INTRODUCTION

In comparison to the other industries, the construction industry is always criticised for its poor performance, productivity and quality (Nesan and Holt, 1999; Oglesby *et al.,* 1989). The construction industry is constantly under the scrutiny for the quality of work (Loushine *et al.,* 2006).

Therefore, to improve the quality in construction, studies in the past have identified various factors that affect the quality of the construction work (Atkinson, 1998; Maloney, 2002; Pheng and Wee, 2001). Some of the factors are poor workmanship, use of unsuitable equipment, use of low-quality materials, lack of supervision, etc. However, out of all these factors, workmanship was found as the most decisive factor to achieve good quality in the construction work (Durdyev *et al.,* 2017; Hoonakker *et al.,* 2010; Love *et al.,* 1999; Mailvaganam and Collins, 2004; Ng *et al.,* 2004). This is because the workmanship is an interface between the materials, equipment, and the executed work.

Although many studies have found the importance of good workmanship for achieving a good quality of work; not much emphasis was given for improving it in the past. Tam *et al.,* (2000) showed that the expected continued improvement in construction quality had not been realised. This is because of the lack of standardisation and empirical knowledge, which makes it difficult to implement the

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Johari, S and Jha, K N (2019) Determinants of Workmanship: Defining Quality in Construction Industry *In:* Gorse, C and Neilson, C J (Eds) *Proceedings of the 35th Annual ARCOM Conference,* 2-4 September 2019, Leeds, UK, Association of Researchers in Construction Management, 761-770.

workmanship principles in the construction industry. Therefore, it is essential to identify those determinants of workmanship associated with the construction workers which impact the quality of the construction work at the sites (Małachowski and Korytkowski, 2016).

This study has focused on the identification of those determinants of workmanship which affects the quality of the construction work executed by the workers at the sites. This aim was achieved in two steps. First, the literature review was carried out, and 10 determinants were identified. In the second step, five key determinants were ascertained from the identified determinants through two independent and parallel investigations covering industry professionals (top-down approach) and the construction workers (bottom-up approach) as experts. Identification of these determinants will help the training providers to strategically alter the existing training curriculum for the workers to focus specifically on the improvement of these key determinants of the workers during training. This eventually would help the industry to resolve the problem of poor quality of construction work at the sites.

LITERATURE REVIEW

Workmanship is defined as a human attribute relating to knowledge and skills at performing a task. This indicates that skill level will influence the quality of workmanship, which in turn can have a positive or negative influence on rework and project costs (Love *et al.,* 1999).

To measure workmanship, researchers have found cost-to-rework as a quantification tool (Durdyev *et al.,* 2017; Durdyev and Mbachu, 2011; Tripathi and Jha, 2017a). Similarly, customer centricity and cost-to-waste were also found as a quantification tool to measure the level of workmanship (Hoonakker *et al.,* 2010; Maloney, 2002; Sommerville, 1994). However, before measuring the level of workmanship, it is essential to identify factors which influence the workmanship.

Mailvaganam and Collins (2004) studied the influence of workmanship on the installation of elastomeric waterproofing membranes. They found that the durability of the final product does not only depend upon the material properties but also on the workmanship. The study established that due to the lack of on-site practice, the workers often adopt wrong working procedures while working, which leads to the delivery of the poor-quality product.

Similarly, Tam and Fung (2012) emphasised on safety while working. They showed that by adopting necessary safety measures during the work, the workers deliver a high level of performance at the sites. This is because their motivation level and morale remain high by using safety measures while working. Along with this, team working skills among the workers were also identified as a significant factor influencing productivity and quality of construction work at the site. Jayasinghe and Fernando (2017) displayed that the team working skills among the workers influences their efficiency; and thus, can be considered as a determinant of workmanship.

In line with the previous studies, Wang *et al.,* (2008) examined the influence of construction craft training and absenteeism on the performance of construction workers in construction firms of the USA. The results revealed that training has a positive influence on the workers. Their performance got improved by reducing absenteeism. Similarly, using the right tools and tackles while working was also found as a significant factor influencing workmanship at the site (Bubshait and Al-Atiq, 1999).

Sommerville (1994) indicated that wastage of material and time while working shows the incompetency of a worker. This influences their performance and thus affects the quality and productivity of the work. Hence, wastage of material and time while working can also be considered as the determinants of workmanship.

From the referred literature, it has been observed that workmanship is an important factor that affects the quality of construction work. However, very few studies have identified the factors influencing the workmanship at the sites. Moreover, those few studies have used top-down approaches for deriving the results. None of the studies has validated the results by using a bottom-up approach. Hence, it is important for the research community as well as the industry to consider the opinion of the construction workers in identifying the determinants of workmanship in order to increase the quality of construction work at the site.

RESEARCH OBJECTIVE

The two key research objectives are as follows:

- To identify the determinants of workmanship
- To establish the key determinants of workmanship

RESEARCH METHOD

The overall research method consists of three steps. These steps are explained in detail in the following sub-sections.

Step 1: Identification of Determinants of Workmanship

By using relevant sources of literature, nine determinants of workmanship were identified that determine the quality of construction work at the site. To check the exhaustiveness/ completeness of the list of these identified determinants for the construction industry, the list of the determinants was personally discussed with three experts. These three experts included one project manager, one project engineer and an experienced construction worker. Each of these experts had more than 15 years of experience in the construction industry. The experts suggested incorporating three more determinants, namely, fickle profession, housekeeping, and task planning to make the list exhaustive. Also, the experts suggested to remove two determinants - cost to rework and user satisfaction - as both of them are the measure of workmanship rather than the determinants. Therefore, after incorporating the suggestions of the experts, a total of 10 determinants were finalised as shown in Table 1.

Step 2: Data Collection

The data was collected from two sources using two different techniques: (i) from industry professional (top-down approach) using Delphi technique, and (ii) from construction workers (bottom-up approach) using questionnaire survey technique. Participants of both groups (industry professionals and construction workers) were working in the Indian construction industry. These two data sources are explained in the following subsections:

Data collection from industry professionals using Delphi technique (top-down approach)

Hallowell and Gambatese (2010) recommended the use of the Delphi method for obtaining a reliable consensus of opinion of experts. The construction skill development council under the Ministry of skill development and entrepreneurship is responsible for developing training standards for the construction workers in India.

These training standards are developed by the 15-member panel of experts who are working as top professionals in various leading construction companies in India. All the 15 experts were contacted, however, only twelve agreed to participate in the study. Out of twelve, responses from ten experts were received in person and two responses via email.

Table 1: List of determinants of workmanship

S. No.	Determinant of workmanship	Sources
1	Absenteeism	(Wang *et al.,* 2008)
2	Fickle profession	Experts
3	Following correct working procedures	(Bubshait and Al-Atiq, 1999; Loushine *et al.,* 2006; Mailvaganam and Collins, 2004)
4	Housekeeping	Experts
5	Safety while working	(Loushine *et al.,* 2006; Tam and Fung, 2012)
6	Task planning	Experts
7	Team working skills	(Jayasinghe and Fernando, 2017)
8	Use of right tools and tackles	(Bubshait and Al-Atiq 1999)
9	Wastage of material while working	(Formoso and Revelo, 1999; Loushine *et al.,* 2006)
10	Wastage of time while working	(Formoso and Revelo, 1999; Loushine *et al.,* 2006)

A self-administered questionnaire was designed based on the identified determinants of workmanship. The question which was posed to the professionals was: 'How much impact does each of the determinants make on the workmanship?' A five-point unipolar Likert scale was used to measure this impact, where, 5 = very high impact, 4 = high impact, 3 = moderate impact, 2 = low impact, and 1 = very low impact. The questionnaire was administered in three rounds in the study as explained subsequently.

Round 1: The responses collected from Round 1 were used to rank the attributes according to their mean value. Also, the summary statistics of the responses such as median, interquartile range and standard deviation were calculated. The summary statistics showed wide variation in the responses, hence, round 2 was conducted to bring consensus in the responses.

Round 2: In this round, the median, interquartile ranges and the comments submitted by all the respondents in the first round were sent back to each of the experts. By providing the first-round responses, the authors tried to make the consensus among the responses of the experts in the second round. Also, if the latest response of the experts was not within the consensus range, the authors asked the experts to justify their response briefly. The authors found significant improvement in the consensus range after evaluating the responses of Round 2.

Round 3: As the authors found notable changes in the responses of the experts in Round 2, another round of Delphi was conducted to check further alteration in the responses by the experts. Hence, similar to Round 2, the authors sent the median, interquartile ranges and the comments of Round 2 to the experts. If still, the response of any of the experts was out of the range of the consensus, the authors asked for the justification in brief. However, analysis of Round 3 brought no further changes in the responses of Round 2. Hence, no further rounds were conducted by the authors.

Data collection from construction workers using questionnaire survey technique (bottom-up approach)

An interviewer-administered questionnaire was designed based on the 10 determinants of workmanship as identified in Step 1. The choice of interviewer-administered questionnaire over self-administered questionnaire was made because of the two main

reasons: unavailability of workers' contact details, and the inability of the workers to read and understand the questionnaire by themselves due to illiteracy.

A similar questionnaire, which was used for industry professionals, was applied for data collection purpose from construction workers as-well. A pilot study was then undertaken to test the language and understanding of the questionnaire. According to the suggestions obtained from the pilot study, some major changes were made in the questionnaire to make it more understandable for the workers. The questionnaire consists of two parts. Part 1 included the questions related to the measurement of the impact of determinants on workmanship, and Part 2 consisted of the demographic profile of the respondents.

The authors conducted this interviewer-administered questionnaire survey at five construction sites in and around close vicinity of New Delhi, India. Multi-storey residential buildings were constructed at these sites. The respondents (construction workers) were primarily belonging to three trades: bar-bending, carpentry, and masonry. Also, to communicate with the workers in their local languages, the authors took the help of the supervisors at the site. These supervisors worked as the interpreter for the authors during the questionnaire survey. A total of 86 valid responses were recorded by the authors.

Step 3: Data Analysis

The data were analysed in four parts. In the first two parts, the determinants were ranked based on the data collected through the Delphi technique and the questionnaire survey technique respectively. In the third part, key determinants of workmanship were identified based on the mean value of each determinant. Subsequently, to check the level of agreement between the responses of the industry professionals and the construction workers over the rankings of the determinants, a correlation test was conducted in the fourth part of the data analysis.

Ranking of the determinants obtained from industry professionals
The data was analysed by using the software package SPSS 20. To check the reliability of the data, Cronbach's alpha was determined. It was found to be 0.772 at 5% significance level, which was greater than 0.5. Hence, it confirms the reliability of the data. To measure the consensus in the opinions of the experts, Relative index rating (RIR) was used. The RIR values for all the determinants in all the three rounds were calculated by using Eq. (1). Also, the attributes were ranked based on the mean value obtained from the responses. The ranks of the attributes based on the responses of the industry professionals are shown in Column 4 of Table 2.

$$RIR = \frac{(Q_3 - Q_1)}{\bar{x}} \times 100 \qquad (1)$$

where Q_3 is the third quartile; Q_1 is the first quartile; $\bar{x}$ is the mean.

Ranking of the determinants obtained from construction workers
Based on the responses collected on a five-point Likert scale, the determinants were ranked according to their mean value. However, when the mean value of two or more determinants was found to be the same, the determinant having lower standard deviation was ranked higher than the others (Tripathi and Jha, 2017b). The ranking of the determinants based on the data collected through the questionnaire survey are shown in Column 6 of Table 2.

Table 2: Ranking of the determinants from top-down and bottom-up approaches

S. No.	Determinant of workmanship	Industry professionals		Construction workers	
		Mean	Rank	Mean	Rank
1	Absenteeism	3.917*	2	2.302	10
2	Fickle profession	3.333	6	4.302*	3
3	Following correct working procedures	3.667*	5	4.663*	1
4	Housekeeping	2.917	8	4.070*	5
5	Safety while working	4.167*	1	4.651*	2
6	Task planning	2.833	9	2.988	7
7	Team working skills	3.833*	3	2.978	8
8	Use of right tools and tackles	3.750*	4	2.837	9
9	Wastage of material while working	3.083	7	4.280*	4
10	Wastage of time while working	2.417	10	3.337	6

**Key determinants of workmanship ($\mu \geq 3.5$)*

Identification of key determinant of workmanship

The mean value of the responses obtained from the descriptive statistical analysis was not a whole number. Therefore, for interpretation purpose, the impact of each of the determinant on the workmanship may be considered to lie between mid-points of two adjacent scales (Tripathi and Jha, 2017a). The degree of impact of the determinants with respect to the mean value (μ) greater and equal to 4.5 was considered as very high impact on the workmanship. Similarly, the range of mean values $4.5 > \mu \geq 3.5$ was treated as high impact; $3.5 > \mu \geq 2.5$ as moderate impact; $2.5 > \mu \geq 1.5$ as low impact; and mean value less than 1.5 was treated as very low impact on the workmanship.

Therefore, those determinants of workmanship which lie in the very high and high degree of impact ($\mu \geq 3.5$) were considered as the key determinants of the workmanship in the study.

Formulation of study hypothesis

To check the level of agreement between the ranking of the attributes given by the industry professionals and the construction workers, the following hypothesis was made:

(i) Null hypothesis (Ho): There is no significant correlation between the rankings of the determinants of workmanship given by industry professionals and construction workers.

(ii) Alternative hypothesis (H1): There is a significant correlation between the rankings of the determinants of workmanship given by industry professionals and construction workers.

To test the above hypothesis, Spearman's rank correlation coefficient (R) test was conducted. This test is a nonparametric test and requires rank data. If the values of coefficient R are not statistically significant at an allowable significance level of, say 5%, then the null hypothesis that there is no significant correlation between the rankings of the determinants given by industry professionals and construction workers cannot be rejected. After applying this test, the results revealed that the rankings were not significant at a 95% confidence interval. It shows that there is a difference in the opinion of the industry professionals and the construction workers on defining the determinants of workmanship.

RESULTS AND DISCUSSION

The aim of this study was to identify and evaluate the key determinants of workmanship. The responses collected from the industry professionals revealed five key determinants of workmanship (Table 2 Column 4). These are safety while working, absenteeism, team working skills, use of right tools and tackles, and following correct procedures while working. These are the results obtained by a typical top-down approach most commonly used by many of the studies in the past (Tam and Fung, 2012; Wang *et al.,* 2008), where the industry professionals identify the solutions of the problems associated with the construction workers, and the considerations are imposed on them (Heckman and Rudelius, 2018). In the authors' opinion, however, the construction workers themselves should be in a better position to identify what is best for them. Keeping this in view, the authors used a bottom-up approach to get a deeper insight into the determinants of workmanship. Interestingly, out of five identified key determinants, the construction workers agreed with only two of them (see ranks 1 to 5 in Column 6 of Table 2), namely, safety while working, and following correct procedures while working.

Safety while working is found to be an important determinant of workmanship. More than 60,000 fatal casualties and 200,000 non-fatal casualties are reported every year around the world (Lingard, 2013). This is mainly because of the use of improper and/or incorrect safety equipment while working. Such fatal and non-fatal accidents reduce the motivation level and morale of the workers at the sites (Li *et al.,* 2012), and, ultimately affects the productivity and quality of the work executed by them. Therefore, to execute the work productively with necessary quality, the workers must adhere themselves to the safety norms by using correct safety tools and equipment while working at the sites. Hence, safety while working was found to be a key determinant of workmanship. Likewise, procedures followed by the workers while working at the site also determines their workmanship. This is because any variation or error in the working procedure can result in poor quality of work (Mailvaganam and Collins, 2004), and thus, the knowledge and ability of a worker to use and apply correct procedures while working were found to be important determinants of workmanship.

Along with these two key determinants, the construction workers highlighted additional three key determinants of workmanship which were not reported by the industry professionals. These are fickle profession, wastage of material while working, and housekeeping.

The fickle profession is the lack of constancy or stability of the workers in the construction industry. The long absence of workers from the construction work results in a low-performance output from them after returning to the work (Durdyev *et al.,* 2017). As construction is not the only occupation of most of the workers in the developing countries, they frequently change their profession from construction to agriculture to manufacturing etc. This substantially hampers their working skills after returning to the construction work, and hence, the fickle profession is found as a key determinant of workmanship. Similarly, wastage of material while working was found as another key determinant of workmanship. Wastage of material is an inefficiency of a worker which results in using larger quantities of material than those that required for construction (Koskela, 1992). This implies that the wastage of material is the result of the incompetence of the workers due to their lack of knowledge, skills and attitude, which ultimately results in delivering a poor quality of

work due to poor workmanship. Along with the wastage of materials, while working, the construction workers also highlighted housekeeping as a key determinant of workmanship. Housekeeping is the habit of cleaning and properly arranging and/or disposing of the materials or waste during and after finishing any activity (Leamon and Murphy, 1995). Thus, the habit of housekeeping will not only result in a cleaner workplace but makes it safer as well. This results in reducing illnesses and injuries also while working and promotes a positive attitude and morale among the workers. Therefore, good housekeeping practices during the work help in substantial improvement in the workmanship at the site.

The difference in opinions of industry professionals and construction workers was put to test through the hypothesis testing. The test results confirmed the differences as well as the respective ranks provided to the attributes by the two groups (industry professionals and construction workers). The prime reason for this difference lies in the fact that the workers are directly attached to the job on the regular basis than the professionals, and therefore are more aware of the inadequacies that impede the workmanship. Resultantly, the thought process of both the groups act on a completely different plane. Therefore, in addition to the existing apprenticeship training programs, where, the training curriculum is more or less developed on the basis of professionals thought process, it is imperative to take workers' consideration also.

CONCLUSIONS

Quality is one of the key project objectives in the construction industry. There are many factors that contribute to achieving good quality at the site; workmanship is one of the decisive factors among them. Therefore, this study attempts to find out the key determinants of workmanship affecting quality of the construction work executed by the construction workers at the site.

The five key determinants of workmanship were identified by rendering the responses from industry professionals (top-down approach) through the Delphi technique. These are safety while working, absenteeism, team working skills, use of right tools and tackles, and following correct procedures while working. It is clear that the industry professionals highlighted those determinants which can be improved by improving the practical knowledge and skills of the workers through existing apprenticeship training programs. However, when the authors applied a bottom-up approach by using interviewer-administered questionnaire from the construction workers, interestingly, out of five identified determinants, the workers agreed with only two of them, namely, safety while working, and following correct procedures while working. Along with these two, the construction workers highlighted additional three key determinants of workmanship which were not reported by the industry professionals. These are fickle profession, wastage of material while working, and housekeeping. The emphasis of these determinants is more on the competence of the workers involving behaviour, attitude and motivation of the workers rather than solely on their working knowledge and skills. This drew an important conclusion that, along with the knowledge and skills of the workers, their competence level gets affected by their behaviour, attitude and motivation also, which in turn affects the workmanship, which needs to be enhanced. Therefore, in addition to the existing apprenticeship training programs, where, the training curriculum is more focused on improvement of the practical knowledge and skills of the workers; training programs are also required to upgrade the workers' behaviour, attitude and motivation which if not taken care, subtly affects even the positive output gained from enhanced skills and knowledge.

Further research is needed to develop the quantitative indices for each of the determinants in order to quantify workmanship, which eventually would help in developing competency-based training programs for the workers. This might prove to be a valuable research.

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