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Investigation of the poor-quality practices on building construction sites in Malaysia

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Abstract: Poor quality occurs in >80% of building projects. They can increase the cost of a building by up to 50% and can delay a project by up to 50%. This research investigated the determinants of poor quality on building on-sites. The research developed a questionnaire instrument that included 20 determinants of poor-quality buildings on construction sites based on literature and site visits. The survey forms were administered to construction sites operatives through hand delivery. A total of 80% of the respondents measured that the poor quality of buildings was caused by the 20 determinants. Poor workmanship, non-compliance with requirements/standards, inadequate site management, failure to achieve high-quality standards, and poor-quality materials/components were the major determinants of the poor quality of buildings during construction. This research provides fresh information on the causes and impact of poor quality on the performance of the building sector.

Keywords: rework, contractors, maintenance-span, building performance, site operatives

1 Introduction

The construction sector is an economic investment and its relationship with economic development and growth is well posited. The sector contributes up to 10% of the Gross domestic product (GDP) and employs >10% of the workforce in many economies (Ashworth 2012; United Nations Economic Commission for Europe 2021). The construction sector conceives, plans and constructs, alters, repairs, and demolishes buildings, engineering works and

other built assets. The success or performance of a construction project is generally defined by items of cost, time and quality. These three dimensions or to simply call them requirements are also defined as the client value system (Olanrewaju 2011; Kelly et al. 2014). However, the value systems of modern clients have expanded to include sustainability, comfort, convenience, aesthetics, image and flexibility (Kelly et al. 2014). Regardless of the number of requirements, clients desire projects that meet their needs and wants. However, the performance of the construction sector is poor. For instance, projects are completed behind schedule, exceeding the budget and with poor quality standards (Egan 1998; Latham 1994; Wolstenholme et al. 2009). In particular, the quality of the finished product is low in the field of construction as compared to other industries. For instance, poor quality has been costing the sector more than the combined profits of the companies in the sector. It was estimated that better quality management could save the UK construction industry up to £12 billion a year (Montague 2018). Similarly, the construction industry of the United States expended \$1,502 billion in 2004 for total construction costs and \$75 billion was wasted by rework costs (Bureau of Economic Analysis 2006). This represents 5% of the value of an investment in the construction sector.

According to Burati et al. (1992), quality deviations in the construction projects accounted for an average of 12.4% of the total project costs. The estimated direct poor quality cost was 21% in Turkey (Kazaz et al. 2005), 8% in Uganda (Kakitahi et al. 2014), 9.4% in Sweden (Josephson et al. 1999), 4% in Australia (Mills et al. 2009) and 5.8% in the UK (Hall and Tomkins 2001). However, research has shown that the indirect cost of rework is about 10 times greater than the direct cost Rosenfeld (2009). Poor quality work in a new building can be due to various factors. The causes have been classified differently, most in terms of design- and construction-related factors (Palaneeswaran 2006; Arditi and Gunaydin 1998; Shohet and Ciabocco 2016). Many studies found that design-related factors were the main cause leading to poor quality (Oyewobi and Ogunsemi 2010; Hwang et al. 2014). However, since >90% of the cost and time of project delivery is used at

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the construction level, it is conceivable that the activities at the construction sites have a significant impact on the quality of buildings. In fact, many studies in the USA (Arditi and Gunaydin 1998), Israel (Shohet and Ciabocco 2016) and Australia (Love et al. 2004) suggested that the activities and decisions that took place on construction sites can significantly mar or improve the quality of the completed buildings. It is, therefore, surprising that most researches about the poor quality of buildings are not conducted at the construction level.

Although representative data on poor quality work on sites are lacking in Malaysia, the growing concern with the subject is increasing unabated (Abdul-Rahman 1993, 1995; Abdul-Rahman et al. 1996; Hong 2016; Al-Tmeemy et al. 2012). In fact, due to the increasing rate of the poor quality of buildings on sites, the construction industry standard (CIS) on the quality assessment system for building construction work was developed by Construction Industry Development Board Malaysia (CIDB) Malaysia in 2006. The standard specifies the requirements on the quality of workmanship and assessment procedures for building construction work. The standard was revised in 2014 as CIS 2014 by adopting components from international standards. To support these standards, the quality assessment system in construction (QLASSIC) was introduced. QLASSIC aims to inculcate quality to developers, contractors, consultants and clients (CIDB 2018). Research on the quality management of buildings in Malaysia has generally focussed on the cost of quality (Abdul-Rahman 1993, 1995; Abdul-Rahman et al. 1996) and the adoption of a quality system (Al-Tmeemy et al. 2012). Fewer studies have been conducted on the causes of poor quality of buildings (Hong 2016; Ahzahar et al. 2011; Yap et al. 2017). Except for Hong (2016), who collected data through interviews based on a case study, the previous studies were based on data collected from respondents from diverse organisational backgrounds and diverse positions. Many of whom do not even have direct contact with the site management. However, the backgrounds and positions of the respondents had an influence on the evaluation of the nature and characteristics of the causes of poor quality in buildings during construction. Focussing on the construction level is very imperative because it concerns the peculiar behaviours of site workers, materials and component installations, methods of construction, plant and equipment, and working environment all of which have a direct impact on the quality of the finished project. Focussing on inspection and rework will incur more costs as compared to prevention and avoidance (CIDB 2018). Therefore, to prevent and control poor-quality buildings, the major task is to examine the fundamental determinants of the poor

quality in the buildings. Without knowledge on the determinants of poor quality, appropriate measures cannot be proposed. It is against this background that this current research sought to investigate the determinants of the poor quality of building projects. Closely related to this is the determination of the rate of occurrence of poor quality in the buildings.

2 Literature review and theoretical framework

The concept of poor quality in buildings is provided in this section. The size, nature and the determinants of poor quality in the buildings were also presented in this section.

2.1 Poor quality, defects, rework and maintenance

There is no consensus on the definition of poor quality in buildings. Defects, rework, poor quality, snagging, non-quality, deviation and non-compliance have all been used interchangeably to denote poor quality. In this article, all the items are synonymous with poor quality. Juran (1999) defined quality as a 'fitness for purpose'. According to the British Standard, the quality of products and services include not only their intended function and performance but also their perceived value and benefit to the customer as referred in British Standards Institution (2015). Quality implies providing customer satisfaction and meeting the required standard (CIDB 2019). It is also defined as meeting the requirements of the customer, such as completion of work without defects and the need for rework, completion of work on time, and within budget. In the construction sector, quality is understood as the ability to meet the requirements of the clients (Kazaz et al. 2005). 'Quality means not only zero defects but doing it right at the first time, delivery on time and to budget, innovating for the benefit of the client, and stripping out waste, whether it be in design, materials or construction, on-site' (Latham 1994). Onishi et al. (2008) defined quality in construction as the risks that occur when the contractor's work does not satisfy the required specifications. A quality building meets all the contractual requirements at the optimum cost and time (Chung 2002). Poor quality in a building is indicated by a defect (Onishi et al. 2008; Watt 1994; Olanrewaju, et al., 2011; Jonsson and Gunnelin 2019). Georgiou et al. (2004) defined a defect as the

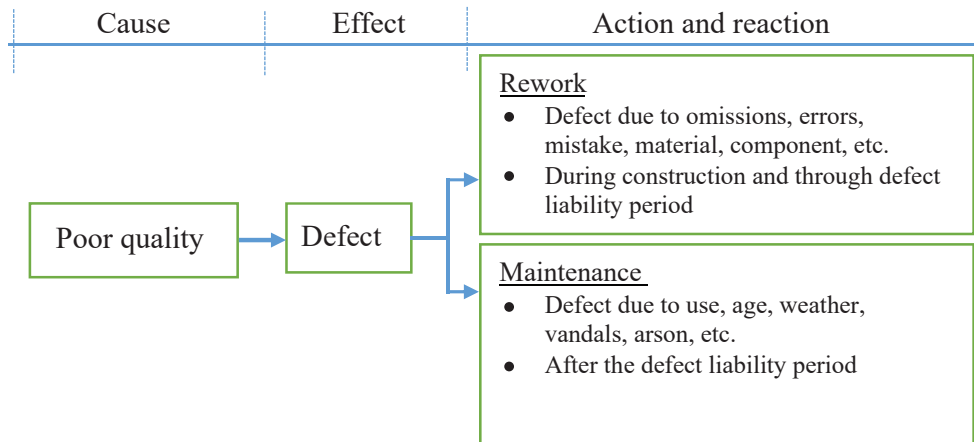


Fig. 1: Relationship between poor quality with rework and maintenance.

shortcoming in the performance of a building. According to Watt (1994), a defect is the falling or shortcomings in the functional performance, statutory or users' requirements of the building. Defects are caused by human errors and work processes (Lee et al. 2018). Defects hinder the functional performance of the buildings and services. Defects do not only influence the occupants'/clients' satisfaction but lead to disputes and litigation amongst clients/users, developers and maintenance organisations (Jonsson and Gunnelin 2019). Defects can manifest within a structure, fabric, services and other facilities Watt (1994).

Defects in buildings might be rectified during construction, the defect liability period or after the defect reliability period. Rework is a rectified defect during the construction phase (Mills et al. 2009). Rework is defined as the unnecessary effort of redoing a process or activity that was incorrectly implemented in the first instance (Palaneeswaran 2006). Like maintenance, rework does not change the functions of the building or its elements. The cost of the rework is often borne by the contractors or design teams, depending on its origin. Maintenance costs are attributable to the clients/users especially if they are determined after the defect liability period. However, if the defect cannot be established to originate from the design/construction activities and processes, the clients/users may bear the cost, even if it is determined during the defect liability periods. Maintenance, as Olanrewaju (2011) explained, is primarily initiated due to usage or defects of which the source is due to misuse, normal wear and tear, and weather. Some design/construction defects are exacerbated by users, weather or other external factors (Olanrewaju, 2012). However, often, if the defect is not technical or if it is determined after the defect liability or during the occupation, the developers often 'pass' (Mills et al. 2009) or transfer the burden to the clients/occupants.

Figure 1 displays the relationship between poor quality, defects, rework and maintenance. Poor quality in a building can be the result of many determinants.

2.2 Size, nature and impact of rework

The quality of a building can be affected during any of the building design processes. Due to the importance of quality costs to construction companies, many construction companies have 'quality management' or a Quality assurance (QA)/Quality control (QC) department. In fact, many design-induced quality problems can be reduced or corrected during the construction phase. However, many of the quality problems are caused or aggravated during the construction phase. Despite the various measures to increase the quality of building projects, the rate of poor quality in buildings is huge and high in the construction sectors. For example, Palaneeswaran's (2006) study showed that the poor-quality cost in Hong Kong could range between 5% and 20% of the original contract value. The author found that poor quality can be reduced by avoiding variations, defects, and errors and by enhancing communication and coordination. The research shows that rework originates from design and construction factors. In Iran, Heravi and Jafari (2014) found that the poor-quality cost was 7.4% of the total cost. In Nigeria, the poor-quality cost was 4.5% of the cost of the project (Oyewobi and Ogunsemi 2010). However, the research revealed that the cost of rework for new buildings (at 5.06%) was higher than rework for refurbished buildings (at 3.32%). Although the research did not discuss the causes of rework, it indicated that the causes of rework varied amongst countries and were related to design and construction activities. Empirical data from a South African study revealed that

the cost of rework to the original contract value was 5.12% (Simpeh et al. 2015). An earlier study in South Africa, by Rhodes and Smallwood (2003), examined rework and found that rework/defects could add 13% to the project price. The study revealed that rework could be attributed to clients and contractors. It was determined that rework accounts for >10% of the projects in Australia (CIDA 1995). Similarly, Burati et al. (1992) found that the direct/tangible cost of quality deviation is 12.4%. In other words, 12.4% is the cost of poor quality in buildings.

Based on the data available for 359 construction projects in the CII (CII Benchmarking and Metrics [BM&M]) database, the direct cost of rework was 5% of the total construction costs in the USA (Hwang et al. 2009). The study revealed that the sources of rework depend on the type, nature, size and location of the project. Empirical data involving contractors, consultants, quantity surveying firms and architecture firms revealed that rework accounted for 24.94% of the construction schedule growth in Singapore (Hwang et al. 2014). Data on the Israeli construction industry showed that poor-quality costs could be up to 14% of the revenues of the construction companies. In Sweden, Hammarlund et al. (1990a, b) and Josephson et al. (2002) estimated that the cost of rework in building projects ranged from 2% to 4%. The research found that the cost of correcting a quality failure was about 6% of the production cost and delayed projects by up to 11%. According to the research, reworks were caused by design factors, site management, errors, omissions, procurement types, and weather. A study conducted in Malaysia showed that the cost of non-conformance on construction sites was between 5% and 6% of the total project cost according to Abdul-Rahman et al. (1996). A study in Malaysia also arrived at a similar value of between 3.1% and 6.0% of the project value (Yap et al. 2017), and recent research in Portugal showed that the cost of the rework could be up to 7% of the contract sum dos Reis Almeida (2011). Research has shown that the cost of poor quality in Dubai represented 1.3% (Abdel-salam and Gad 2009).

From the foregoing, considering the impacts of poor quality on building performance, contractors, clients, developers and users, this research aims to investigate the determinants of poor quality in buildings from the perspectives of the site operatives. This research also determines the rate of occurrence of poor quality in buildings. The knowledge on the determinants will provide opportunities to reduce rework and improve project performance and profits, and satisfaction. Multiple pieces of evidence have reiterated that to control poor quality, there is a necessity to investigate the determinants of poor

quality (Love et al. 2005; Simpeh et al. 2015; Olanrewaju 2010; CIOB 2019a, b; Palaneeswaran 2006). However, a major area of quality management in the building delivery process that is consistently neglected in research is the area of the determinants of poor quality on sites. The reason for this, as Loves and Edward (2004) explained, is because the attitude of the construction companies is leaned heavily towards being detection-focused. In other words, resources are not focused on prevention but rather on correcting defects. This is a reactive approach, however. A systemic approach is to develop a problem-seeking approach. Examining the determinants of poor quality and defects is akin to accepting the endemic nature of the poor quality and defects in the buildings (CIOB 2019a, b). In fact, the possibility of rework occurrence in a building project is close to 80% (Hwang et al. 2009; Simpeh et al. 2015). Adopting a problem-seeking approach will enable the deployment of measures and techniques to solve the problem. Poor quality has multiplier effects on performance, productivity, and profit of the construction companies and increases construction costs, and delays the project. It also leads to disputes and claims with the various parties to the projects. Therefore, another question that demands an answer is 'What is the rate of the occurrence of poor quality in the buildings?'

2.3 Determinants of poor quality on construction sites

The poor quality of building projects has been attributable to various causations. Unlike cost and time, the quality of a project lacks clarity. Whilst some studies have found that design-related practices and processes had a major influence on poor quality (Hwang and Yang 2014; NEDO 1987; Burati et al. 1992; Tawfek et al. 2012). The construction phase was also found to have significant impacts on poor quality work. Cnuddle (1991) found that 46% of quality failures were due to design whilst 22% were due to construction deviations. But, according to BRE (1981), 40% of the quality failures occurred at the construction stage. NEDO (1988) found that 30% of the defects in housing occurred at the construction stage. In Sweden, it was determined that 50% of the defects in buildings originated from site activities (Josephson et al. 2002; dos Reis Almeida 2011; Hammarlund et al. 1991) research showed that about 70% of the rework was due to construction-related activities. Therefore, the main activity to improve the quality of a finished building is to examine the determinants of poor quality in the building on construction sites.

In general, many studies have been conducted on the causes of rework/poor quality (Love et al. 2005; Hwang et al. 2009; Hwang et al. 2014; Burati et al. 1992; Love et al. 1999; Fayek et al. 2003) on a construction project. Whilst many of the previous studies used data from third parties (such as housing associations) most of the studies combined data from the design team, construction team, third party agencies and client together. Kazaz et al. 2005; Kakitahi et al. 2013; Rahimia et al. 2017; used case study as source of data collection. Also, some of the studies involved various types of construction projects such as buildings, infrastructure and heavy engineering (Love et al. 2005; Hwang et al. 2009). However, data from respondents from diverse backgrounds have a significant impact on the findings. In Malaysia, only a few studies have examined the causes of rework. For instance,

Ahzahar et al. (2011) investigated the causes of failure and defect factors in the construction industry. The research identified eight factors as the causes of rework in the industry. The survey collected data from both consultant and contractor organisations. Along the same path, Yap et al. (2017) investigated the causes of rework of building projects. They identified 18 rework factors. Hong (2016), however, relied on data from the construction sites. Whilst the research was unique, only a few causes of rework were identified. Table 1 contains a list of determinants of poor quality in buildings based on previous literature. The determinants of poor quality in buildings are displayed in Figure 2. The classification was based on the RIBA Plan of Work 2020 (RIBA 2020). The plan presents a framework for construction projects that are suitable for the preparation of detailed professional services and

Tab. 1: Summary of previous studies on determinants of poor quality

Criteria	Main author
Lack of skilled labour	Ali and Wen (2011), Hoonakker et al. (2010) and Olanrewaju et al. (2021)
Lack of worker empowerment/incentive	Loushine and Hoonakker (2002), Marosszeky et al. (2002), Hiyassat (2000) and Pheng and Wei (1996)
Poor interpretations of client/customer expectations	Loushine and Hoonakker (2002) and Olanrewaju et al. (2021)
Design complexity	Tang et al. (2004), Chan and Tam (2000), Olanrewaju et al. (2021), Olanrewaju (2021) and Olanrewaju et al. (2011)
Inadequate focus on client/customer requirement	Hoonakker (2006) and Olanrewaju et al. (2021)
Employee involvement/altitude	Hoonakker (2006) and Olanrewaju et al. (2021)
Lack of management commitment	Janipha and Ismail (2013), Ogwueleka (2013), Joaquin et al. (2008), Husin et al. (2008), Hoonakker (2006), Jha and Iyer (2006), Hiyassat (2000) and Arditi and Gunaydin (1998)
Poor communication	Mane and Patil (2015), Janipha and Ismail (2013), Ogwueleka (2013), Ali and Wen (2011), Ofori (2006), Hoonakker (2006) and Arditi and Gunaydin (1998)
Tight project schedule	Husin et al. (2008)
Variations	Ogwueleka (2013), Husin et al. (2008) and Joaquin et al. (2008)
Poor coordination between project	Ogwueleka (2013), Tang et al. (2004), Husin et al. (2008), Joaquin et al. (2008), Hoonakker (2006), Jha and Iyer (2006) and Arditi and Gunaydin (1998)
Poor planning/scheduling process	Mane and Patil (2015), Ofori (2006) and Chan and Tam (2000)
Expertise knowledge or training system	Yung and Yip (2010) and Arditi and Gunaydin (1998)
Poor time management	Ali and Wen (2011) and Olanrewaju et al. (2021)
Lack of quality assurance/Quality policy	Ali et al. (2010), Ogwueleka (2013), Joaquin et al. (2008) and Arditi and Gunaydin (1998)
Lack of project supervision	Janipha and Ismail (2013), Ogwueleka (2013), Husin et al. (2008) and Arditi and Gunaydin (1998)
Unavailability of resources	Joaquin et al. (2008), Chan and Tam (2000) and Olanrewaju et al. (2021)
Project environment	Ogwueleka (2013) and Joaquin et al. (2008)
Uniqueness of the project	Ogwueleka (2013), Joaquin et al. (2008) and Husin et al. (2008)
Insufficient project manager	Mane and Patil (2015) and Ofori (2006)
Lack of training policy	Mallawaarachchi and Senaratn (2015), Ogwueleka (2013), Said et al. (2009), Joaquin et al. (2008) and Olanrewaju (2012)

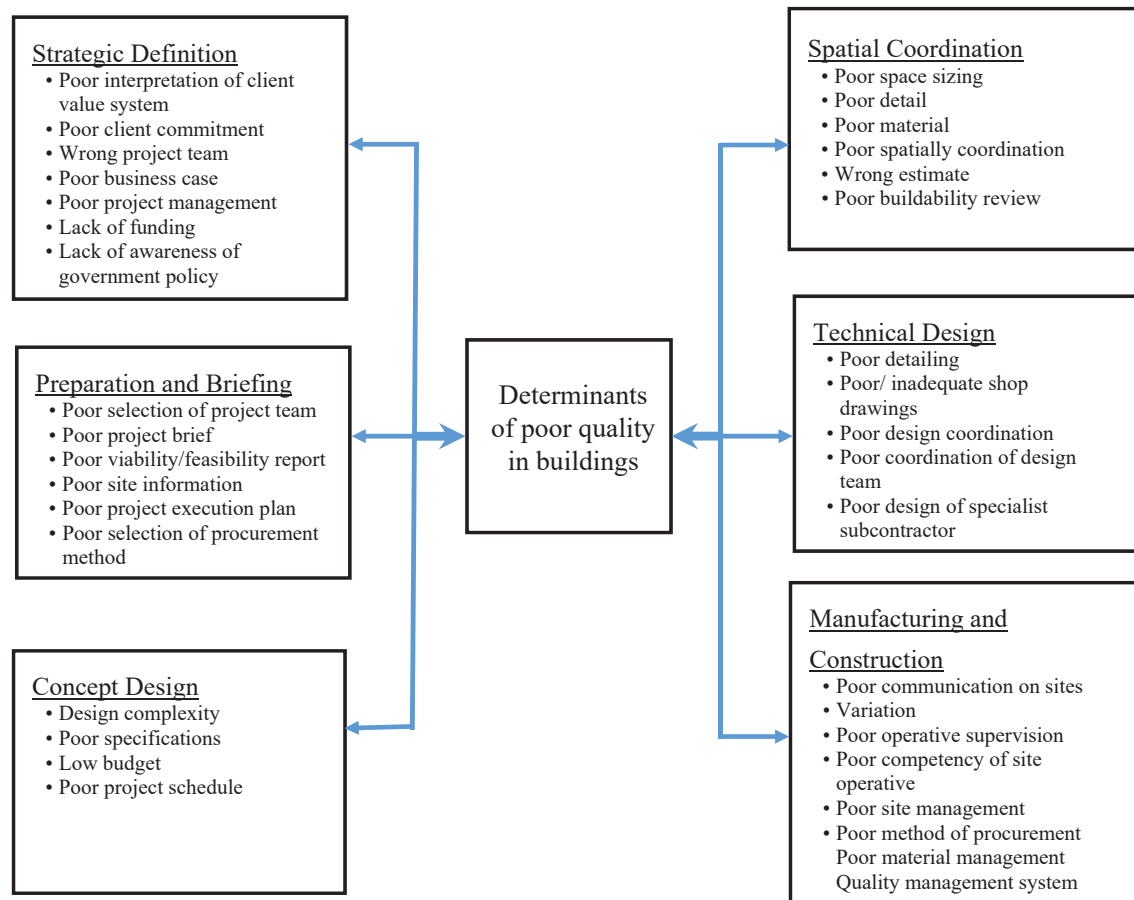


Fig. 2: Determinants of poor quality in building projects.

building contracts. The plan of work organises the process of a construction project in eight phases. These phases are (0) Strategic Definition, (1) Preparation and Briefing, (2) Concept Design, (3) Spatial Coordination, (4) Technical Design, (5) Manufacturing and Construction, (6) Handover and (7) Use. However, because of the poor quality or rework is before the operation phase of the buildings (see phase (1)), the phases (6) and (7) are not included in the figure. Work in these two phases will be grouped under ‘maintenance works’ and not under poor quality/rework.

3 Research methodology and analytical techniques

This research used a literature review and a survey questionnaire to achieve its aim. The literature review was conducted to identify the existence of gaps in knowledge. Whilst a few research have investigated the poor quality of buildings in Malaysia, there is a lack of empirical research on the determinant of poor quality from those involved in

site operations only. Whilst taking into account the heterogeneity in data collection may increase coverage and may ensure diversity of the research’s finding, commonly, it will lead to clinical heterogeneity which normally arises due to differences in participants’ characteristics. The variability in the data may introduce systematic bias into the conclusion. The major limitation of the clinical heterogeneity is that it often leads to significant statistical heterogeneity, inaccurate summary, lack of specificity and other similar limitations. For contextualisation and applicability of the research finding, our research focused on homogeneity in the data collection. The data were collected through hand delivery based on convenience sampling. In the case of convenience sampling, the survey is administered to available, accessible and willing respondents. Convenience sampling is a very suitable procedure to collect primary data, especially where it is not easy to access the respondents and if the exact size of the population is not known. It can be used for both explanatory and exploratory research. As Olanrewaju and Idrus (2020) explained, convenience sampling is appropriate for research with a limited timeframe and cost. However,

the main shortcoming is that the findings may not be generalised. However, with a large sample size, the findings can be indicative of the population (Sekaran and Bougie 2019). This conclusion is in tandem with the principle of the central limit theorem (CLT). The survey questionnaires were administered to site operatives on the building sites on 26th and 27th June 2019 and 4th–8th July 2019. The questionnaire went through two pilot surveys involving construction operatives. The determinants were developed from an extensive literature review (see Table 1) and a discussion with those involved with the site activities. The respondents were asked based on pieces of evidence to tick the degree to which they agreed that each of the determinants would lead to poor quality of building projects based on sites activities. The degrees of the agreement were measured on a five-continuum scale; where ‘5’ denoted extremely agree and ‘1’ denoted strongly least agree, ‘3’ denoted agree, and ‘2’ and ‘4’ were located in between. The determinants were positively worded. The degree of the determinants and the occurrences of poor quality is measured by the Average Relative Index (ARI) Eq. (1) and the standard deviation (SD).

$$ARI = \frac{\sum_{i=1}^5 a_i x_i}{5 \sum_{i=1}^5 x_i} \times 100 \quad (1)$$

Where a_i was the index of a group, constant expressing the weight given to the group; x_i was the frequency of the responses, $i = 1, 2, 3, 4$, and 5 and was described as below: x_1, x_2, x_3, x_4, x_5 where the frequencies of the responses corresponding to $a_1 = 1, a_2 = 2, a_3 = 3, a_4 = 4, a_5 = 5$, respectively. For interpretation, an ARI scored of 1.00–20.00 denoted least agree, 21.00–40.00 denoted less agree/often, 41.00–60.00 denoted agree/often, 61.00–80.00 denoted very agree/often, and 81.00–100.00 denoted extremely agree/often. Thus, the determinant with the highest ARI score was considered as the major factor.

There was a pooled difference of 1.0% between each of the scales. The computed statistical tests were the one-way test, ARI, reliability tests, mode, and SD. All data gathered adopted the IBM SPSS 25 for the data analytics. The analyses involved the descriptive analysis and diagnostic and predictive analyses. The one-sample t-test was conducted to examine whether each of the determinants contributed to poor quality or not.

4 Results

A total of 284 forms were administered. However, a total of 106, representing a 37% response rate, completed survey forms were returned. The results are presented and discussed in the following sections.

4.1 Alysing the respondents’ profiles

Tables 2 and 3 show the results of the respondents’ profiles. The data revealed that >43% of the respondents had Bachelor’s degrees and 46% had obtained diplomas and Sijil Pelajaran Malaysia (SPM), or the Malaysian Certificate of Education/Malaysian Higher School Certificate (Sijil Tinggi Persekolahan Malaysia) (Table 2). Most of those with BSc degrees were site quantity surveyors and many were site engineers or site supervisors. About 50% of those with diplomas were site supervisors and >45% of the respondents with SPM/STPM were site supervisors. Close to 70% of the respondents worked with main contractors whilst the remainder worked with subcontracting organisations (Table 3). A total of 40% of the respondents’ organisations had completed >six projects in the last 5 years. To draw insight from the data, it was obvious that the respondents had adequate knowledge and competency to provide unbiased and valid information.

Tab. 2: Cross-tabulation between current position and academic background

Current position	Academic background					Total
	PMR	SPM/STPM	Diploma	Bachelor degree	Master	
Site engineer	0	0	2	14	1	17
Site supervisor	0	4	12	9	0	25
Safe and health officer	0	0	3	2	0	5
Site quantity surveyor	0	0	2	15	0	17
Quality officer	0	1	1	3	1	6
CM	0	0	1	2	1	4
Site worker/labourer	8	21	2	1	0	32
Total	8	26	23	46	3	106

CM, construction manager; PMR, Penilaian Menengah Rendah (Lower Secondary Assessment).

The subcontracting organisation had more rework than the main contractors (Figure 3). This was not surprising because most construction projects were executed by subcontractors in Malaysia.

All the completed building projects had poor quality. See Figure 3. The rate of poor quality in 73% of the projects ranges from 21% to 60% (Figure 4). Only about 1% of the projects have up to 100% reworks. However, about 60% of the construction work had major poor quality. The CII, BM&M (The BM&M) database showed that of the 1,057 reported projects, rework was not reported for 229 projects (Hwang et al. 2009). To interpret, 80% of the projects have been reworked. In Singapore, 58% of the construction projects were reworked (Hwang et al. 2014). As Table 4 revealed, the higher the number of projects executed, the higher the number of poor-quality occurrences. A plausible implication of this is that the contractors are sacrificing time and cost for quality work. The pressure may be from the clients or the contractors or both.

4.2 Analysing the hierarchy of the determinants of poor quality in building projects

The goodness of the measures of the data was conducted using a Split reliability test, validity test (communalities), one –sample *t*-test, and The Kaiser-Meyer-Olkin (KMO) and Bartlett's Test. The results of the reliability showed that the consistency of the data was very high at 0.764 (Table 5). Guttman Split-Half Coefficient of >0.7 implies that the internal consistency of the data is high and thus reliable. The combined average validity results

for all the determinants were 0.684 (Table 6). Table 6 also contains the results of the one-way *t*-test showed that the data were generally statistically significant. The null hypothesis was that each of the determinants would not lead to poor quality building on sites ($H_0: U = U_0$). The research hypothesis was that the determinants would lead to poor quality building on sites ($H_r: U \geq U_0$). U_0 was the population mean. The *t*-test revealed that the results were substantially statistically significant. However, some of the determinants were not significant. In other words, there was a noticeable disagreement with the measurement of the respondents with these determinants. A possible reason for this could be attributable to the nature and characteristics of the site operations that the respondents were involved. In fact, when the critical factor was set at 3.0, all the factors were significant. The standard errors were very small. A small standard error is an indication that a sample mean is very similar to the population parameters. Kaiser's Measure of Sampling Adequacy was significant ($\chi^2(190) = 716.692, p < 0.001, N = 0.677$), indicating that the data were drawn from the same population and that the determinants were related.

Tab. 3: Cross-tabulation between the type of organisation and number of projects completed in 5 years

Type of organisation	Number of project completed			
	0–5	6–10	11–15	Total
Main contractor	49	19	5	73
Subcontractor	17	15	1	33
Total	66	34	6	106

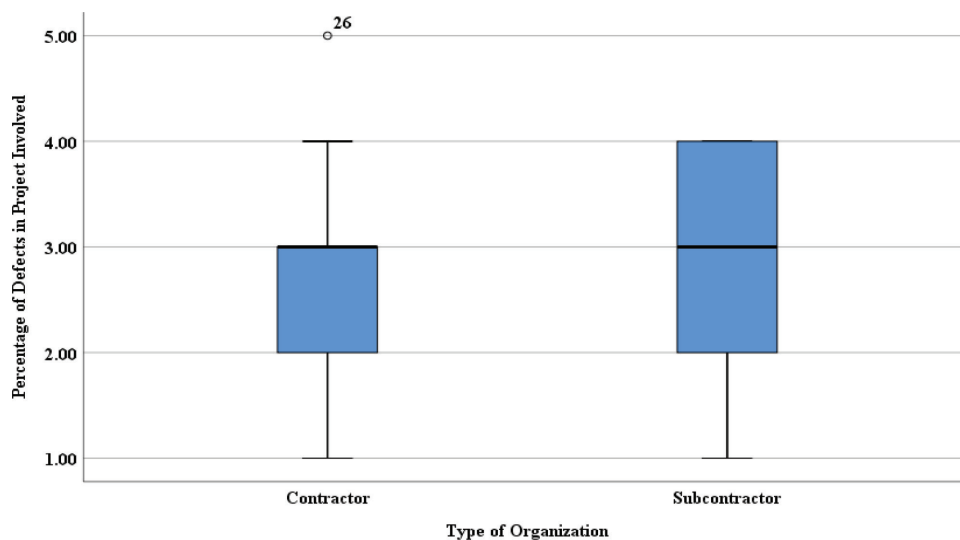


Fig. 3: Boxplot for type of organisation against the percentage of poor-quality project.

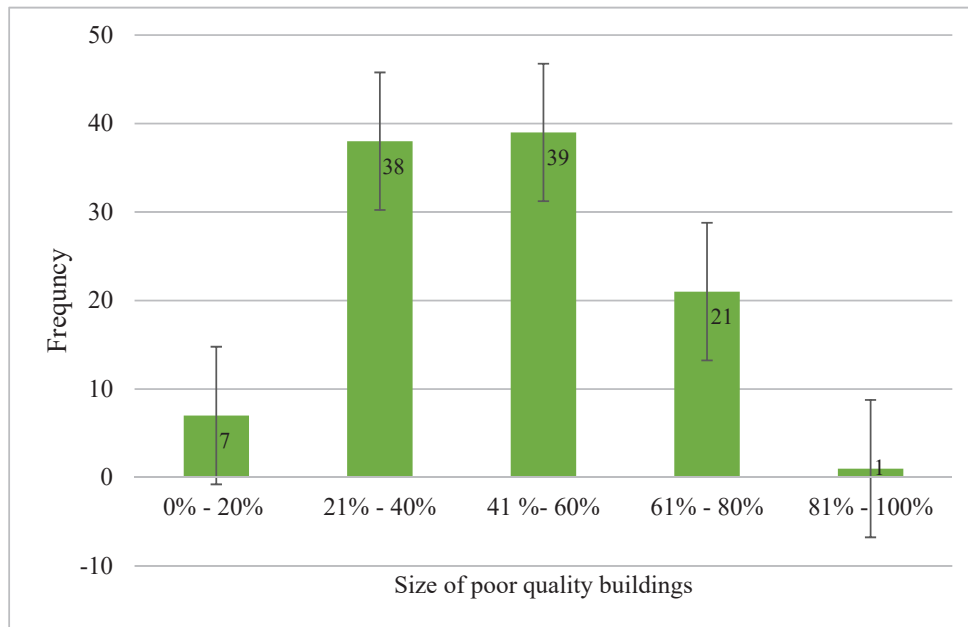


Fig. 4: Percentage of projects with poor quality.

Tab. 4: Correlations Spearman's rho

		Percentage of defects in the project
Number of projects completed	Correlation coefficient	0.329*
	Sig. (2-tailed)	0.001
	N	106

*Correlation is significant at the 0.01 level (2-tailed).

The results also signified a lack of multicollinearity amongst the determinants. Collectively, the interpretations of these statistics are that the determinants and their measurements were appropriate to achieve the aim of the research.

The descriptive statistics on the hierarchy of the determinants are contained in Table 7. The survey found that about 48% of the respondents very agreed or extremely agreed with the causes of the poor quality of the buildings on sites. Approximately 39% of the respondents measured that the determinants would lead to poor quality. The remaining 14% believe that determinants have less or least on the quality of the buildings. The composite ARI score for all the determinants was 69.085%, whilst the composite SD was 15.271%. Scrutinise the association between the SD and the mean score implies that nearly all the respondents measured that the determinants would lead to poor quality work. The ARI for all the determinants

Tab. 5: Reliability statistics

Cronbach's alpha	Part 1	Value	0.686
		N of items	10 ^a
	Part 2	Value	0.706
		N of items	10 ^b
	Total N of items		20
Correlation between forms			0.618
Spearman-Brown coefficient	Equal length		0.764
	Unequal length		0.764
Guttman split-half coefficient			0.764

^aThe items are: Incompetency of labour, Operative high workload, Poor site supervision, Poor competency of site supervisor, Poor coordination of subcontractors' works, Construction method, Poor quality procedure, Design complexity, Incomplete drawings and specifications, Poor/incomplete shop drawings.

^bThe items are: Low quality of materials, Improper material storage, Usage of wrong equipment and plants, Rework/changes, Poor communication on site, Variation, Project duration, Weather condition, Wrong information on nature of sites, Poor information on government policy.

ranged between 54% and 83%. Based on the index in Section 4, two of the determinants were found to be the extreme determinants of poor-quality building projects, and 16 of the determinants would lead to poor quality of buildings to a high extent. Figure 5 illustrates the determinants of poor quality in buildings from the lowest determinants to the highest determinants.

Tab. 6: Results of a sample t-test for the determinants of poor quality

Determinant	Test value = 3.5						Std. deviation	Std. error mean
	<i>t</i>	df	Sig. (2-tailed)	Mean dif- ference	95% Confidence interval of the difference			
					Lower	Upper		
Incompetency of labour	1.085	105	0.281	0.075	−0.063	0.214	14.329	1.392
Operative high workload	0.530	105	0.597	0.038	−0.103	0.179	14.651	1.423
Low welfare for workers	−0.845	105	0.400	−0.066	−0.221	0.089	16.099	1.564
Poor site supervision	5.789	105	0.000	0.434	0.285	0.583	15.435	1.499
Poor competency of site supervisor	−0.448	105	0.655	−0.028	−0.154	0.097	13.008	1.263
Poor coordination of subcontractors’ works	−0.621	105	0.536	−0.047	−0.198	0.104	15.647	1.520
Construction method	2.215	105	0.029	0.170	0.018	0.322	15.789	1.534
Poor quality procedure	4.301	105	0.000	0.302	0.163	0.441	14.454	1.404
Design complexity	3.305	105	0.001	0.264	0.106	0.423	16.458	1.599
Incomplete drawings and specifications	−1.944	105	0.055	−0.160	−0.324	0.003	16.990	1.650
Low quality of materials	9.488	105	0.000	0.642	0.508	0.776	13.922	1.352
Improper material storage	−9.736	105	0.000	−0.821	−0.988	−0.654	17.358	1.686
Usage of wrong equip- ment and plants	−2.324	105	0.022	−0.170	−0.315	−0.025	15.048	1.462
Rework/changes	0.966	105	0.336	0.066	−0.070	0.202	14.080	1.368
Poor communication on site	−1.944	105	0.055	−0.160	−0.324	0.003	16.990	1.650
Variation	−2.595	105	0.011	−0.179	−0.316	−0.042	14.222	1.381
Project duration	−6.627	105	0.000	−0.491	−0.637	−0.344	15.243	1.481
Weather condition	0.000	105	1.000	0.000	−0.139	0.139	14.409	1.400
Wrong information on nature of sites	−0.361	105	0.719	−0.028	−0.184	0.127	16.144	1.568
Poor information on government policy	−10.269	105	0.000	−0.755	−0.900	−0.609	15.134	1.470

5 Discussion of the findings

Various studies have indicated that poor quality is costing construction companies a significant part of their profits. Poor quality is also causing many projects to be completed behind schedule and leading to disputes and claims. Whilst poor quality is often ascribed to design-related factors, the impact of the construction activities on the quality of buildings is huge. Design-induced reworks, such as errors, mistakes and omissions in the design, can be identified and rectified at less or no cost during the construction phase. This research found that if the quality of the material was poor it would lead to poor quality buildings. In fact, none of the survey respondents measured

this determinant to have less or least impact on the building. The research found that defective materials and improper installation of the materials will lead to defects in buildings (Ahzahar et al. 2011; Kakitahi et al. 2013; Yap et al. 2017). The quality of the workmanship on sites is a major determinant of project performance. Regardless of the completeness of the design and the material used, if the quality of the workmanship for the installation is poor, the final building projects will be defective. Therefore, it is not unexpected for this research to find that the competencies of the workers on the construction sites were very important determinants of the quality of the buildings. In support of this, Yap et al. (2017) opined that poor workmanship will increase the rate of defects in buildings.

Tab. 7: Descriptive statistics of the determinants of poor quality

Determinant	Least agree	Less agree	Agree	Strongly agree	Extremely agree
Incompetency of labour	0	6	41	51	8
Operative high workload	0	7	43	48	8
Low welfare for workers	1	9	48	39	9
Poor site supervision	0	2	29	49	26
Poor competency of site supervisor	0	3	56	41	6
Poor coordination of subcontractors' works	0	9	50	37	10
Construction method	0	7	35	50	14
Poor quality procedure	0	5	25	62	14
Design complexity	0	6	33	47	20
Incomplete drawings and specifications	0	16	48	32	10
Low quality of materials	0	2	13	59	32
Improper material storage	2	52	34	14	4
Usage of wrong equipment and plants	3	39	41	16	7
Rework/changes	0	6	41	52	7
Poor communication on site	0	16	48	32	10
Variation	0	11	54	37	4
Project duration	1	26	51	27	1
Poor weather condition	0	7	46	46	7
Wrong information on nature of sites	0	14	35	50	7
Poor information on government policy	2	40	48	15	1

In fact, major quality standards like The Construction Quality Assessment System (CONQUAS) in Singapore (Hwang et al. 2014) and the QLASSIC in Malaysia seek to improve the quality of the workmanship on sites with the two quality standards. Poor workmanship has been identified as a major factor that would cause reworks from the subcontractor's perspective (Palaneeswaran 2006).

Site supervision is very critical in the building delivery process. Studies (Palaneeswaran 2006; Love et al. 2014; Yap et al. 2017) identified the importance of site supervision on rework. However, to provide the needed supervision that is capable of reducing reworks, the competency of the site supervisors is very critical. This research found that >80% of the survey respondents agreed that the competency of the supervisor was very critical. A complex design is a design that is complicated and sophisticated, and therefore it is difficult to construct. Complicated design often leads to poor quality buildings, especially if the site operatives are not familiar with the types of design (Fisk 2003; Kelly 2007). Simplification of the design is a method to reduce the cost of construction and defects (Lee et al. 2018; CIOB 2019a, b; Olanrewaju and Abdul-Aziz 2015). Love and Edwards' (2004) study

indicated that design complexity and size have a positive connection with rework.

Quality certifications provide opportunities for construction companies to adhere to certain guidelines in conducting their businesses to deliver buildings at a minimum cost, on time, and to achieve a high-quality standard. In fact, Love and Edwards (2004) reported that the rework cost of a construction company in Australia dropped from 5% of the contract value to 1% after implementing some quality assurance systems. In Malaysia, QLASSIC was set up as the standard for the construction stakeholders. Developers and contractors that have adopted the QLASSIC have been reported to deliver high-quality buildings. Therefore, adopting good quality procedures will serve to reduce defects. Similarly, the poor-quality procedures will lead to rework, as this research has revealed. Statistically, >80% of the survey respondents measured that poor-quality practices will lead to poor quality buildings. Having quality procedures do not mean that rework will not occur, but at least it will be substantially reduced. In fact, a Singaporean study showed that, even with the implementation of ISO 9000, ISO 9001, and CONQUAS, rework has remained a significant challenge in

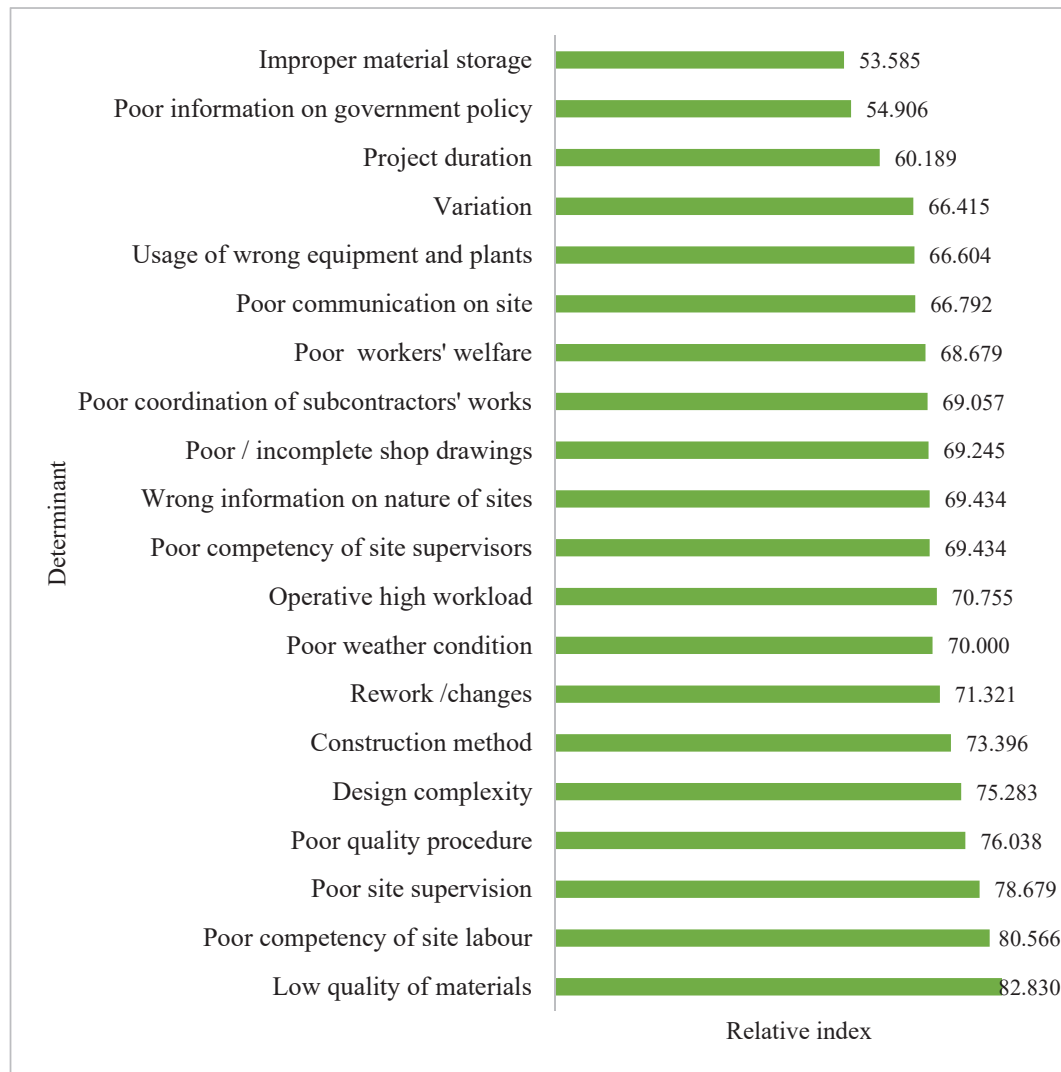


Fig. 5: Priority of determinants of poor quality in building projects.

the construction sectors (Hwang et al. 2014). Also, a study in Portugal also confirmed that having ISO certification does not automatically mean that the company may not have rework dos Reis Almeida (2011). The situation is not different in Malaysia (Yatim and Zakaria 2008).

Our research has revealed that the construction method is a major determinant for poor quality in buildings. Several studies have revealed that inappropriate methods of construction will lead to poor quality work. The method of construction affects workflow through the use of technology (RICS 2018). The extent of technology has a significant impact on the amount of on-site operation required. If most of the elements are manufactured off-site, quality tends to improve and, to a large extent, reduces rework. Although off-site work will increase the quality of the work, it tends to reduce the number of changes that are possible on-site and whilst the building

is in operation. However, if site operatives are not familiar with some of the modern construction methods, it may lead to poor-quality buildings. This has been reinforced based on recent research conducted by RICS (2018). The RICS research found a lack of familiarity with off-site construction techniques will lead to risk-averse decisions against its use. Additionally, although construction companies and the government have continued to promote the adoption of the industrial building system (IBS), the adoption rate is very low. Recent research in Malaysia revealed that <20% of the contractors had adopted the IBS. In fact, there were <150 companies that manufactured IBS elements. Two major factors are responsible for the low adoption of IBS in Malaysia. The first is cheaper foreign labour. An increase in the salaries and incentives to the labourers would incentivise the contractors and developers to invest in the mechanisation of the site operations.

The second reason for the low adoption of the IBS is the weather. Malaysia's weather is 'very good'. There is a long period of construction activities. The temperature and humidity are conducive to perform site operations with little disruptions.

The survey respondents also believed that rework could lead to poor quality. While the inclusion of the rework in the list seems counter-intuitive, it is not surprising. Rework is typically conducted on an adhoc basis and without any lessons learned. Poor quality rework has an effect on another part of the project if the rework is not properly executed according to the specifications and drawings. In the process of reworking a defective part, other parts would be affected. Similarly, if the poor quality is not properly rectified, it will lead to rework, thereby increasing the chain of the poor-quality buildings. Burati et al. (1992) found that most quality failures in buildings when they have not been correctly corrected or repaired on time as soon as they have occurred. In fact, based on Hammarlund et al.'s (1990) finding in Sweden, 80% of the quality failures were not even rectified at all. Work-related stress is a serious concern in the construction sector as about 90% of site operatives claimed that their jobs were stressful as reported in a survey involving construction sites (Beswick et al. 2007). Another study that surveyed the construction industry revealed that 68.2% of the respondents claimed to have suffered from stress, anxiety or depression, and 154 had taken medical advice (CIOB 2006). Stress would lead to loss of productivity and poor execution of work. To put it differently, if construction workers have a high workload, it will lead to poor quality. This background tends to support the measurement of the respondents concerning the determinant of poor quality. Most of our survey respondents agreed that the workload of the workers would lead to poor quality in buildings.

The weather condition has a profound impact on the quality of work. Rain could damage materials in the store, could force operatives to stop work at any time and could damage/destroy work in progress. Evidence from multiple studies has led to the conclusion that weather has an impact on the quality work of the rework (Yap et al. 2017; Hwang et al. 2014; Aljailawi and Shariatmadar 2017; Tawfek et al. 2012). According to CIOB (2019a, b), using off-site construction can reduce the impacts of the weather on the quality of work. This research found that a lack of information on the nature of sites would lead to poor quality. The primary responsibility of a client to the success of a construction project is to own the land and provide adequate information to the design construction teams. The client is also expected to provide access

to the teams to conduct a site investigation before the design and drafting of the specifications. In Malaysia, it is often the responsibility of the clients to provide reports of the site condition to the contractors before tender. But, often the information that is provided by the client team has always been inaccurate and incomplete, which may not be helpful in the preparation of a realistic estimate. Contractors must be allowed to conduct a site investigation before tender. Contractors cannot prepare accurate estimates, shop drawings, and procure the appropriate materials and components without reliable information on the nature of the site. Therefore, it can be seen that the respondents prioritise wrong information on the nature of the sites as a major determinant of poor quality. It is interesting to find that the next determinant of poor quality is incomplete shop drawings. Shop drawings are produced by contractors based on the design team's drawings and specifications (Arditi and Gunaydin 1998). However, if the information in the contract documents and the site is not similar, it would manifest in poor quality work. Therefore, it has become imperative to produce contract documents based on reliable information on the nature of the site. However, it is expected that shop drawings are prepared based on contract documents and site information. The approval of the design team should be received before the installation of the building elements/components.

The effective management of a construction operation can only be achieved through a well-coordinated team effort (Fisk and Rapp 2004). Our data revealed that poor coordination of subcontractors would lead to poor quality of work. More than 90% of the survey respondents measured that poor coordination of subcontracting work would determine the quality of the work to a greater extent. The procurement strategy chosen for the building scheme will have a direct impact on how the project is coordinated. Based on a recent survey that investigated the size of the work that the main contractor awards to subcontractors, it is noted that >90% of the work is awarded to subcontractors. The functional organisations in the project are many. In fact, for small buildings, >50 subcontractors and trade units may be found. Without proper coordination of the activities of the various functional organisations, the quality of the project could be affected. The various organisations, as Simpeh et al. (2015) explained, have different objectives and if the works are not properly coordinated and integrated, it may lead to rework. A lack of coordination would lead to loss of productivity and waste of materials (Love et al. 2005; CIOB 2019a, b).

The welfare of construction workers is very important. If the welfare of the site labour is low, they may not be motivated to be productive. In fact, many motivational

theories that were developed to increase labour productivity, loyalty and reduce turnover found that taking care of the welfare of the site labour is very critical. Josephson et al. (2002) showed that a lack of motivation could contribute to 50% of the poor work in buildings. Low welfare may lead to mental health issues in the construction industry. In Iran, construction companies motivate the staff to improve work quality by increasing their salaries (Heravi and Jafari 2014). The salary of construction operatives was also identified in the Egyptian construction sector to increase production (Tawfek et al. 2012). According to CIOB in 2019, mental health issues in the construction industry were a 'silent epidemic'. Research and media reports have shown the poor working conditions that construction site operatives undergo. Against this background, it is expected that this research has found that the low welfare of the workers will lead to poor quality buildings.

A good method of communication is paramount to convey information (i.e. drawing, specifications and items for production). Studies have shown that poor communication is one of the major problems in the construction sector (Palaneeswaran 2006; Love et al. 2005; Simpoh et al. 2015). According to CIOB (2019a, b), special attention is necessary to communicate project requirements to the construction team. Olanrewaju et al. (2017) identified the various impacts of poor communication in the Malaysian construction industry. The research showed that poor communication leads to multiple effects, including stress, loss of productivity and profits, and defects in construction projects. Well-communicated information on project quality would help to improve the project performance in terms of cost, time, quality, sustainability and comfort. Tangentially, this research found that poor communications on sites would lead to poor-quality buildings. However, it is surprising that the rating on the impact of poor communication as measured by the respondents is low compared to some of the determinants. Many site operators are foreigners and they need to understand the local language (Bahasa Melayu) to be able to communicate effectively. The outcome of this research implies that contrary to our anticipation, the foreign labourers on sites can communicate effectively in the local language. However, as the finding shows, about 66% of the respondents measured that poor communication was a major source of the poor quality of the buildings.

Poor plants and equipment were also found to lead to poor quality work. Yap et al. (2017) and Ahzahar et al. (2011) also found that the condition of plants and equipment could lead to rework in buildings in Malaysia. The construction method influences the level of mechanisation

on sites. Plants and equipment are vital on construction sites because construction materials and components are heavy and sometimes harmful. Plants and equipment are used to increase productivity and efficiency. If the equipment and plants are not appropriate, rather than increasing productivity and efficiency, it would reduce the efficiency and productivity rate and increase the rate of poor quality in the buildings. However, what was obvious during the visits was that for many of the pieces of equipment and plants, once damaged, they were not repaired correctly on time. To increase the quality of the work, therefore, the plants and equipment that need repair/replacement should be identified and repaired/replaced according to the quality standard.

According to multiple studies (Yap et al. 2017; Palaneeswaran 2006; dos Reis Almeida 2011; Love et al. 2005) change order will lead to poor quality. A change order is any work initiated by the design team/clients that is beyond the contract provision. The change order has a corresponding impact on contract value and schedule (Fisk 2003). Variations or change orders are issued by the design team on behalf of the clients to change a certain aspect of the project that has been correctly executed to meet the latest requirements and preferences of the client. Once a project or part of it is completed, it is often expensive to rectify it. To reduce rework, variation should be reduced significantly (Jaafari et al. 1994). However, the major cause of the variation in traditional procurements is the briefing method. Briefing as a method of collecting and organising the client value system has been severally critiqued (Kelly et al. 2014; Kelly 2007) because it is repetitive, complex and imprecise. In place of the briefing, innovative processes such as value engineering and value management have been suggested (Olanrewaju, 2011). Value management makes the client's value system explicitly clear at the project's conceptual stage.

Building clients require the project to be completed within certain periods of time. However, either cost or time, or both are sacrificed for quality requirements (Olanrewaju, 2011). Often, because of time, quality materials are not supplied and concrete is not allowed to probably set before the commencement of the next work. For instance, plastering is not allowed to dry properly before applying paint to the walls. As a result, poor quality will ensue in the building. Due to such malpractices in the industry, the government has provided many standards. However, due to a lack of communication or violations, the standards are not correctly applied or used on many construction sites. Based on an investigation conducted on selected construction sites, the CIDB found that 63% of the construction personnel investigated were

not registered with the CIDB, 82% of the construction workers were not accredited in their skill trades and 31% of sub-contractors were not registered with the Construction Industry Development Board Malaysia (CIDB 2019). Material storage is one of the major drivers and issues that determine the quality of the buildings during site operations (CIOB 2019a, b).

6 Research implications and limitation

This research has contributed to the little body of knowledge on the determinants of poor quality of building works in Malaysia. Future research should investigate the determinants of poor quality and the contribution of each element to poor quality costs and consequences based on building typology. The main reason for this centres upon the studies conducted by Jaafari et al. (1994), Walker (1994 cited in Love and Edwards 2004) and Naoum and Mustapha (1994) that the building types affect rework and work performance. This research has investigated poor quality in the buildings from the site operation perspective. However, a major limitation of this research is probably the sample size. Therefore, future research could attempt to increase the sample size. It will be interesting if future research can also increase the number of determinants and elements. Future research should examine the measures to reduce poor quality during the site operation process. The determinants and measures to reduce poor quality at the component and trades should be investigated in future.

7 Conclusion and recommendations of site operatives

The survey involved operatives in the building industry. Site operations have significant impacts on building performance. Past and present studies have examined the rework and failures in buildings, yet many poor-quality problems in the design, construction and maintenance continue to reduce the functional value of buildings. The impacts of poor quality on operation costs and on the satisfaction of clients are very high. This research has analysed the major determinants of poor-quality buildings based on on-site activities and practices. In tandem with findings from most economies, poor quality in a building is high in Malaysia and is determined by various determinants,

such as poor workmanship and poor quality of materials/components. However, all parties, including construction managers (CM), consultants, project managers, engineers, etc. must be able to perform the stipulated supervisions. Proper inspections of work and workers should be accorded due recognition. The quality management of the construction requires scrutiny to improve building performance. Apart from adhering to the CIDB guidelines and standards to improve the quality of workmanship, the contractors and subcontractors need to formulate a procedure for monitoring workers and supervisors. The guidelines or standard operating procedures should indicate the levels of supervision and investigation that each of the building elements requires. Material management processes require strengthening. The various quality management systems should be updated and the operatives need to attend refresher courses to update their knowledge and skills. The resident engineers (RE), resident architects (RA), and the resident CM should give clear and decisive instructions and provide adequate and timely responses to contractors' questions and queries. The RE/RA should make certain that qualified workmanship is used. Quality assurance might not be effective if this is not the case. Running a quality management system is not sufficient for delivering quality buildings because the 'quality standard' could be wrong or simply be that the workers may not adhere to its implementations.

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