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Assessment of building construction defect causes in North Shoa zone, Ethiopia

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Ethiopia is one of the developing countries; and many projects are being carried out with some of the firms acting unprofessionally, leading to lots of defects in buildings. This study was focused on identifying the types of defects and assessing the causes of defects occurring in residential and office buildings located in North Shoa zone, Ethiopia. To identify the types and causes of defect, questionnaires surveys were distributed for persons involved in the construction industry including clients, consultants and contractors. The data received in the questionnaires were analyzed by Relative Importance Index (RII) method to determine the relative importance of each factor, and the Spearman rank correlation coefficient was determined to test their significance. Observations were also done on buildings that suffered from the defects in the study area; and foundation, wall and window bay cracks were observed. The top causes of the defects in building construction in the study area according to data collected were lack of consultant timely response and proper solutions; unavailability of professionals for material control; delay of construction material delivery; shortage of construction equipment; and lack of coordination between professionals during design. The Spearman rank correlation for causes of defects in the building indicated that there is no positive significant relationship between stakeholders. These results showed that there was a problem of taking responsibility. Finally, to minimize the problem of defects, various minimizing measures should be taken. These may include; control the quality of design, provide appropriate supervision, train professionals on construction and manpower management, arrange the meeting for stakeholders for proper communication and coordination, and creating awareness on construction defects.

Key words: Construction, defect, defect causes, Relative Importance Index (RII), correlation analysis, minimizing defect.

INTRODUCTION

The environment of construction is constantly changing and the authorities' actions continuously give new conditions. There is an obvious need for continuous improvement within construction but defects will affect the construction systems. Building defects are categorized as structural and non-structural defects. Structural defect means any defect in a structural element of a building that is attributable to defective design, defective or faulty workmanship or defective material, and sometimes any combination of these. Whereas a non-structural defect in

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building is described as a defect in a non-structural element of the building as a result of defective residential building work (Waziri, 2016). There are several building defects which usually occur to building parts such as roofs, walls, floors, ceiling, toilets, doors and windows; these common building defects are crack on walls, peeling paint, rising dampness, defective plaster rendering and roof defects (Wen and Mydin, 2013).

According to Juran and Gryna (1988), a cause is defined as a proven reason for the existence of a defect. Often there are several causes of the same erroneous action. There may be either combined causes or a chain of causes. For this reason, the term "root cause" is used to describe the most basic cause of an undesirable condition. Researches by Hammarlund et al. (1990) showed that the principal driving force behind improvement is knowledge of the improvement possibilities. Knowledge of where defects occur is necessary in order to focus upon where improvement measures are most effective. The study concerns defects found on construction sites during production. Their causes can, however, be referred to other project phases.

The design process is known as a central process in building development project and an expert, such as an engineer or an architect, is the one who will be able to determine the construction problem involved due to the result of improper design, material, or workmanship. The design process has to go through few stages, and there are seven steps which include inception and feasibility, outline design, scheme design, design for legal requirements, detail design, production monitoring and feedback from the operation. Each design decision will promote the building quality and determine the building performance otherwise if one will miss causes of defects (Chohen et al., 2010, 2011; Formoso et al., 1998).

In most situations, the individual who gave rise to a defect had the necessary knowledge and right information for the specific task, but they suffered from lack of motivation. Half of the total defect costs were classified as lack of motivation. More than 1/4 of the defect costs were caused by lack of knowledge and 1/8 by lack of communication, while a small part was ascribed to stress and risk (Table 1). The distinction between these groups is naturally very difficult, which means that the results should be used with caution. Forgetfulness, carelessness and conscious defects were observed and they contributed for motivation defects and related factors with different percentages. The conception of motivation implies that defects are made intentionally. However, the study shows that just a few defects are intentional and that they are caused by non-employed peoples (Josephson, 1998).

According to Atkinson (2002), the managerial errors accounted for more than 82% of all the building defects and these errors have been hidden, and suggesting that such errors were not visible at the construction stage. The study of seven buildings through observations and surveys by Josephson and Hammarlund (1996) showed that 32% of all defects costs were originated from client and design, 45% from site management and approximately 20% from materials and machines.

On the other hand, according to Ahzahar et al. (2011), the major factors that govern building defects are; climatic conditions, a location of a building, construction materials, building type and change in use, maintenance of a building, faulty design and lack of supervision. Thus, a number of studies of defects in construction have been performed at international level. However, the environment of construction is changing rapidly, as well as differing between different cultures; therefore, it is important to repeat such studies. Most studies are broad and unsophisticated surveys, that is to say, not scientifically based. There is a great need for more extensive and deepened studies. The main objective of this study was to assess the basic building construction defect causes in North Shoa zone of Ethiopia. Specifically, identifying types of defect occurs in buildings; assessing causes of defect occurs in buildings; and recommending measures to minimize building defects mostly focuses on residential and office houses.

METHODOLOGY

Study area and its design

Four woreda towns were selected for this study because the towns are close to our working place, and relatively, they have active construction sites in the zone. These towns are Shewa Robit, Enewari, Arerti and Debre Berhan towns located in North Shoa zone, Ethiopia. Debre Berhan University is located in Debre Berhan town, which is our work place. The research was carried out by collecting input data from client, contractor and consultant professionals including site observations. And by reviewing different literature works, problems which occurred in these towns were identified. In each town, out of four to five residential and office buildings, the expected life time is 50 years and they are built in the last three years as were observed. In this research the questionnaires were distributed in these towns for available respective bodies during the study.

Data processing and analysis

The questionnaires collected from respondents were analyzed using Microsoft Excel application. The questionnaires data analysis was determined to establish the relative importance of various factors that contribute to the causes of construction defects. The data received from questionnaires were analyzed by Relative Importance Index (RII) method to determine the relative importance of the factors causing defects in construction projects; identified by the literature survey Kometa et al. (1994) and Sambasivan and Soon (2007), used the RII method to determine the relative importance of the various causes. RII is given by:

$$\mathrm{RII} = \frac{\sum \mathrm{W}}{\mathrm{A} * \mathrm{N}} \quad (1)$$

Table 1. Direct causes of defects in design, production management and workmanship (Josephson, 1998).

Cause	Design	Production management	Workmanship
Lack of knowledge	44	34	12
Lack of information	18	11	6
Lack of motivation	35	42	70
Stress, shortage of time	2	5	1
Risk	1	8	11
Total	100%	100%	100%

(ranges from 1 to 5), where '1' is less significant and '5' is extremely significant. A = highest weight (that is, 5 in this case), and N = total number of respondents.

To study the strength of the relationship between two sets of ranking, the Spearman rank correlation coefficient was determined. Many researchers Divya and Ramya (2015) and Sambasivan and Soon (2007) followed this approach and Spearman's rank correlation coefficient (r_S) is a reliable and fairly simple method of testing both the strength and direction (positive or negative) of any correlation between two variables. Spearman's rank correlation coefficient (r_S) may be computed for the three group of respondents; the correlation between clients and contractors, clients and consultants, and contractors and consultants.

The Spearman rank correlation coefficient is calculated using the Equation:

$$r_S = 1 - \frac{6\sum d^2}{(N^3 - N)} \qquad (2)$$

Where: r_S = Spearman rank correlation coefficient. d = difference in ranking between the two correspondents; contractor and consultant or contractor and client or client and consultant. N = the number of variables.

The value of the Spearman rank correlation coefficient range from –1 to +1; and the positive higher values indicate that there is a high degree of agreement between the respondents. Whereas, the negative value indicates that the correlation between the respondents is strongly disagreed. The Spearman rank correlation coefficient, r_S = –1 means that the rankings have a perfect negative association. They have the exact reverse ranking to each other.

Testing the significance of r_S

The significant relationship of correlation between the rankings of responsible construction parties was tested using the computed Spearman rank correlation coefficient and the critical spearman rho (ρ) estimated using the number of variables and level of significance.

The r_S calculated from a sample of data is an estimate of ρ, the Spearman rank correlation coefficient that would be obtained from the entire population of data from which the sample collected. A common desire in rank correlation analysis is to test the null hypothesis that there is no correlation in the population between the paired ranks.

The significance of r_S was tested using the value of the Spearman's rho coefficient ($\mathbf{r_S}$) that was calculated as test statistics and refer the critical value from the table according to the specified significance level. The accurate critical value for 3 and greater factors was determined by Ramsey (1989).

RESULTS AND DISCUSSION

Group of respondents and their profile

The study used purposive samplings to select key informants from all categories of respondents which were adequately selected, and the following formula was used to generate the required samples:

$$s = (p/P)\,x\,S \qquad (3)$$

Where: s = sample required. p = number of key resource persons. P = study population. S = total sample size.

A total of 80 questionnaires were distributed to client, consultant and contractor professionals, but 58 questionnaires were returned which represents 72.5% to assess the perception of them on the causes of construction defects and its effect on project implementation. In this study the questionnaires were distributed in these towns for available respective bodies during the study. The data collected from the questionnaire survey were presented in tables and statistically analyzed using the RII and Spearman's rank correlation coefficient. Distribution of the questionnaires and the percentage returned were presented in Table 2 and the respondent's profile was expressed in Table 3.

Causes of construction defects

In this study, causes of building construction defects are analyzed in three related factors:

i. Defects related to construction materials.

ii. Defects related to Design quality.

iii. Defects related to the Construction management.

Defects related to construction materials

Defects in construction may result from material selection based on site condition; lack of construction material testing; improper handling (placing) for long period;

Table 2. Questionnaires distribution.

S/N	Respondent party	No. of questioner distributed	No. of questioner filled and returned	Percentage returned (%)
1	Consultants	20	13	65
2	Client	30	20	66.67
3	Contractors	30	25	83.33
Total		80	58	72.5

Table 3. Respondent profile.

Description of respondent		Construction party						All respondent	
		Consultant		Contractor		Client			
		Freq.	%	Freq.	%	Freq.	%	Freq.	%
Gender	M	10	76.9	20	80.0	16	80.0	46	79.31
	F	3	23.1	5	20.0	4	20.0	12	20.69
Age (years)	<24	2	15.4	3	12.0	3	15.0	8	13.79
	25 - 30	5	38.5	16	64.0	11	55.0	32	55.17
	31 - 40	2	15.4	6	24.0	5	25.0	13	22.41
	>41	4	30.8	2	8.0	2	10.0	8	13.79
Educational background	13 and above					1	5.0	1	1.724
	B. Sc degree	12	92.3	20	80.0	15	75.0	47	81.03
	M. Sc degree	3	23.1	5	20.0	4	20.0	12	20.69
Experience	<2	1	7.7	8	32.0	6	30.0	15	25.86
	>2 - 5	4	30.8	12	48.0	8	40.0	24	41.38
	>5 - 10	2	15.4	3	12.0	5	25.0	10	17.24
	>10	6	46.2	2	8.0	1	5.0	9	15.52
Position	Forman			2	8.0			2	3.448
	Site engineer			16	64.0			16	27.59
	Office engineer	3	23.1	3	12.0	7	35.0	13	22.41
	Construction engineer			2	8.0			2	3.448
	Supervisor	10	76.9			13	65.0	23	39.66
	Construction manager			2	8.0			2	3.448

delivery of poor quality material that is not based on specification; and lack of quality control. The primary factors for causes of the defect in view of consultant, client and contractor are variables. This was a fact not only in this category but also on the other category. Table 4 showed that the ranking of the factors based on its RII value in each group of respondents are different and this indicated that there were problems of taking responsibility in the industry. Client claimed that the selection of material problem is the major causes of the defect in construction projects, whereas, consultant put handling of material, and contractor perceives improper schedule for material delivery. According to all respondents, lack of construction material quality control activity was the significant cause of the defect. In addition, delay inconstruction material delivery was also a recognized cause of the defect.

Defects related to design quality

The design quality category, summarized in Table 5, improper and incomplete design conducted by less skilled professionals was a result of the defect by the perception of consultants. Client professionals argued that poor quality design output was the remarkable cause of defect in this category. Whereas, contractors claim the lack of coordination between architectural, structural, electrical and sanitary professionals during design were the significant causes of the defect; and all stakeholder respondents prioritized the factor as a primary factor sharing the lack of consultant professionals' experience.

Table 4. Defects related to construction materials.

S/N	Factor	Consultant		Client		Contractor		Three Party	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
1	Selection of materials according to the site condition	0.462	5	0.610	1	0.424	7	0.497	6
2	Material delivery not based on the specification	0.477	4	0.560	3	0.456	5	0.497	6
3	Material stocked for a long period and not placed in a proper way	0.600	1	0.520	7	0.440	6	0.503	5
4	Lack of construction material testing during design and construction	0.508	2	0.530	6	0.488	4	0.507	4
5	Lack of consultant participation during construction material selection and test	0.431	6	0.540	4	0.536	2	0.514	3
6	Delay for construction material delivery	0.415	7	0.540	4	0.600	1	0.538	2
7	Unavailability of professionals for material control (due to financial difficulty of carelessness)	0.508	2	0.590	2	0.520	3	0.541	1

Table 5. Defects related to design quality.

S/N	Factor	Consultant		Client		Contractor		Three Party	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
1	Lack of design quality control by the client (lack of presentation in the participation of different professionals)	0.431	6	0.540	3	0.488	4	0.493	6
2	Lack of consultant professionals experience	0.446	5	0.560	2	0.552	2	0.531	1
3	Poor design quality due to lack of finance	0.477	4	0.570	1	0.488	4	0.514	4
4	Improper and incomplete design; and design by non-skilled professionals	0.600	1	0.450	6	0.552	2	0.528	3
5	Lack of coordination between architectural, structural, electrical and sanitary professionals during the design	0.508	3	0.500	5	0.568	1	0.531	1
6	Design without proper site investigation/soil test	0.538	2	0.530	4	0.472	6	0.507	5

Table 6. Defects related to construction management.

S/N	Factor	Consultant		Client		Contractor		Three Party	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
1	Shortage of Construction equipment	0.446	5	0.640	1	0.504	3	0.538	2
2	Lack of proper consultant supervision	0.385	7	0.580	4	0.568	2	0.531	3
3	Lack of consultant timely response and proper solutions	0.446	5	0.610	2	0.584	1	0.562	1
4	Delay of payment for the contractor	0.538	1	0.550	5	0.504	3	0.528	5
5	Delay of payment for consultant	0.508	2	0.600	3	0.488	6	0.531	3
6	Weak communication between construction parties	0.477	3	0.540	6	0.472	7	0.497	6
7	An incompetent team of contractor	0.477	3	0.390	7	0.504	3	0.459	7

Defects related to construction management

Delay payment to the contractor and shortage of construction equipment were the first causes of defect by the perception of consultant and client respectively based on their RII. In fact, shortage of construction equipment was the second factor next to lack of consultant timely response for causes of the defect in all respondents agreed.

Lack of consultant timely response was a significant and remarkable cause of defect in the construction industry by the perception of the contractor as well as by the aggregate response of all respondents (client, contractor and consultant) as shown in Table 6.

Table 7. Top five causes of the defect perceived by respondents.

Rank	Client	Consultant	Contractor
1	Shortage of Construction equipment	Material stocked for a long period and not placed in a proper way	Delay for construction material delivery
2	Lack of consultant timely response and proper solutions	Improper and incomplete design; and design by non-skilled professionals	Lack of consultant timely response and proper solutions
3	Selection of materials according to the site condition	Design without proper site investigation/soil test	Lack of consultant professionals experience
4	Delay of payment for consultant	Delay of payment for the contractor	Lack of coordination between Architectural, Structural, Electrical and Sanitary professionals during the design
5	Unavailability of professionals for material control (due to financial difficulty of carelessness)	Lack of construction material testing during design and construction	Lack of proper consultant supervision

Table 8. The cumulative top five causes defect perceived by respondents.

Rank	Factor
1	Lack of consultant timely response and proper solutions
2	Unavailability of professionals for material control (due to financial difficulty of carelessness)
3	Delay of construction material delivery
4	Shortage of construction equipment
5	Lack of coordination between architectural, structural, electrical and sanitary professionals during the design

Top causes of defect

The top causes of the defect in construction according to the perception of the client, consultant and contractor professionals were summarized in Table 7. The perception of professionals to rank causes of defect in construction varied depending on their staff membership characteristics. But in cumulative of all respondents' perception, lack of consultant timely response and providing the appropriate solution was primarily responsible for causes of the defect. Lack of construction material quality control activities (unable to assign professionals) was the second significant factor causing the defect. As summarized in Table 8, delay of construction material delivery; shortage of construction equipment; and lack of coordination between different design team were the next causes of defect respectively.

Correlation analysis

Spearman's rank correlation coefficient (r_S) is a reliable and fairly simple method of testing both the strength and direction (positive or negative) of any correlation between the two variables. Spearman's rank correlation coefficient (r_S) is computed for the three groups of respondents; a correlation between clients and contractors, clients and consultants, and contractors and consultants. The Spearman rank correlation coefficient was calculated using Equation 2 indicated in the methodology.

Correlation between construction parties for defects related to construction materials

The correlation coefficient between consultant and contractor can be computed using the ranking difference between them and square it, and the number of factors considered in the category; for instance, seven factors were considered in client-related factors. The correlation coefficient between consultant and client, and client and contractor are computed in a similar way and it is summarized in Table 9.

Testing the significance

(a) Hypothesis: Assuming the two-tailed test
H_O: $\rho = 0$
H_A: $\rho \neq 0$

Table 9. Spearman rank correlation coefficient of ranking of consultant, client, and contractor for defects related to construction materials.

S/N	Factor	Consultant rank (1)	Client rank (2)	Contractor rank (3)	Difference in ranking		
					d_{12}	d_{13}	d_{23}
1	Selection of materials according to the site condition	5	1	7	4	-2	-6
2	Material delivery not based on the specification	4	3	5	1	-1	-2
3	Material stoke for a long period and not placed in a proper way	1	7	6	-6	-5	1
4	Lack of construction material testing during design and construction	2	6	4	-4	-2	2
5	Lack of consultant participation during construction material selection and test	6	4	2	2	4	2
6	Delay of construction material delivery	7	4	1	3	6	3
7	Unavailability of professionals for material control (due to financial difficulty or carelessness)	2	2	3	0	-1	-1
			Σd_{ij}^2		82	87	59
			r_s		-0.46	-1	-0.05

b) Test statistic

r_S = -0.46

c) Critical value

Number of causes (sample), N = 7

Assuming a 5% significance level, α = 0.05

Critical r_S = 0.786 (Ramsey, 1989)

d) Decision

Spearman's correlation coefficient (r_S) between consultant and contractor is greater than critical value that is, $r_S|-1| = 1 >$ 0.786 = critical r_S ; and therefore *reject the null hypothesis*. Whereas for other correlation; therefore *fail to reject the null hypothesis*.

There is a negative significant relationship between consultant and contractor on defects related to construction materials as a cause of construction defect at 5% level of significance. This indicated that the respondents of consultant and contractor strongly disagree. Similarly, there are also no negative significance relationship between consultant and client, and client and contractor at 5% level of significance since $|r_S| <$ Critical r_S ; that is, $|-0.46| = 0.46 <$ 0.786 and $|-0.05| = 0.05 <$ 0.786 respectively. But the result indicated that the respondents of each party disagree with each other (Table 10).

Correlation between construction parties for defects related to design quality

Testing the significance

a. Hypothesis: Assuming the two-tailed test

H_O: ρ = 0

H_A: ρ ≠ 0

b. Test statistic

r_S = -0.91, -0.26 and -0.11

c. Critical value

Number of causes (sample), N = 6

Assuming a 5% significance level, α = 0.05

Critical r_S = 0.886 (Ramsey, 1989)

d. Decision

Spearman's correlation coefficient (r_S) between consultant and client is greater than critical value that is $r_S|-0.91| = 0.91 >$ 0.886 = Critical r_S; and therefore *reject the null hypothesis*. Whereas, for other correlation; therefore *fail to reject the null hypothesis*.

There is a negative significant relationship between consultant and client on defects related to design quality as a cause of construction defect at 5% level of significance. This indicated that the respondents of consultant and contractor strongly disagree. Similarly, there are also no negative significance relationship between consultant and contractor, and client and contractor at 5% level of significance since $|r_S| <$ Critical r_S; that is $|-0.26| = 0.26 <$ 0.886 and $|-0.11| = 0.11 <$ 0.886 respectively. But the result indicated that the respondents of each party disagree with each other (Table 12).

Correlation between construction parties for defects related to the construction process and its control

Testing the significance

a. Hypothesis: Assuming two tailed test

H_O: ρ = 0

H_A: ρ $\neq$ 0
b. Test statistic
$r_s =$ -0.36, -0.45 and 0.3
c. Critical value
Number of causes (sample), N = 7
Assuming a 5% significance level, α = 0.05
Critical $r_s =$ 0.786 (Ramsey, 1989)
d. Decision

Spearman's correlation coefficient (r_s) between all correlations are smaller than critical value that is $r_s|-0.45| = 0.45 <$ 0.886 = Critical r_s ; $r_s|-0.26| = 0.26 <$ 0.886; and $0.3 <$ 0.886 and therefore reject *the null hypothesis*.

There is neither positive nor negative significant relationship between consultant and contractor, consultant and contractor, and client and contractor on defects related to the construction process and its control as a cause of construction defect at 5% level of significance.

Even if there were no significant relationship between parties, the result indicated that the respondents of each party disagree with each other except the relationship between client and contractor (Table 14).

The correlation analysis indicated that there were no any positive significant relationships between the groups of respondents (Tables 11 and 13). These are results of construction parties' inability to take responsibility for any problem occurred in the construction industry. In many occasions in Ethiopia, contractor professionals push risks to consultant and/or client and vice versa. These made construction industry handicapped in several projects. Many institutions' day to day service faced obstacles; building became nonfunctional leading to a loss of many lives etc.

Conclusion

The study had an objective to assess the causes of construction defect in North Shoa zones of Ethiopia construction projects. To achieve the objective, questionnaires were prepared including causes of the defect with three related category and effects of defects to assess the perception of clients, contractors and consultants participation in the construction industry. The data received in the questionnaire were analyzed by RII method to determine the relative importance of the factors causing defects, and critical effects of defects in construction projects. The Spearman rank correlation coefficient was determined to test its significance.

Due to complexity in design, supervision by consultant is required during the construction process. For those woreda towns especially Shewa Robit, Arerti and Enewari districts, the supervisors are municipalities and they were simply supervised, and controlled quality of the construction based on prepared designs. They were not responsible for design defects but in Debre Berhan town the selected projects was in Debre Berhan University and all of the constructions were supervised and designed by independent consultant, and they were responsible for quality control and design related problems. For those woredas without the consultant, the contractor will solve the design problems on site but it affects the clients in different perspectives. But in all these woreda towns the first identified problem was lack of consultant timely responses and proper solutions were not delivered, mainly due to lack of skilled manpower and the motivation of the construction bodies.

Lack of supervision was occurred to control the quality of materials based on specification due to non-experienced professionals assigned by the consultant and respective offices. Timely construction material delivery is the other identified problem leading to construction gaps due to projects spending long period out of contract time resulting in the project affected by different weather conditions and producing high construction costs. Most of the private owners building construction materials were delivered by the owners resulting in high construction gaps and encoring high costs. For governmental projects, the material deliveries were done by the contractors themselves. But for both private and governmental projects, material delivery problem was observed due to material specification problem, lack of materials locally and poor scheduling for material delivery based on contract time. Shortage of construction equipment was also a problem for building construction as observed in different sites of the study area from simple concrete vibrator; and mixer were not available in some sites. Generally, building construction started from design using client's interest with different professionals' participations. But in the design stage, the main problem with those different professionals (that is architect, structural, electrical, geotechnical and sanitary engineers) was not well coordinated to see the gaps that occurred in design stage as they mostly work independently. Due to the lack of coordination between these professionals, mistakes and different problems were observed at the time of construction.

Finally, the discussions were focused on most previously identified top five overall construction defects from the client, consultant and contractor responses and observations. All the details were discussed in the analysis topic which is defects related construction materials, design quality and construction process; and its control as the main factor with the perspectives of clients, consultants, and contractors and ranked independently.

Recommended solutions of defects

Based on the identified causes of building construction defects for the study, the following possible measures were recommended.

Table 10. Testing the significance of correlation of defects related to construction materials.

Ranking		Consultant	Client	Contractor
Consultant	r_S	1	-0.46	-1*
	Critical r_S	-	0.786	0.786
	Significance	-	Not significant	Significant
Client	r_S	-0.46	1	-0.05*
	Critical r_S	0.786	-	0.786
	Significance	Not significant	-	Not significant
Contractor	r_S	-1	-0.05	1
	Critical r_S	0.786	0.786	-
	Significance	Significant	Not significant	-

*The negative Spearman's correlation coefficient (r_S) indicates the negative direction of the relationship and the result shows, its correlation is not negatively significant.

Table 11. Spearman rank correlation coefficient of ranking of consultant, client and contractor for defects related to design quality.

S/N	Factor	Consultant rank (1)	Client rank (2)	Contractor rank (3)	Difference in ranking		
					d_{12}	d_{13}	d_{23}
1	Lack of design quality control by the client (lack of presentation in the participation of different professionals)	6	3	4	3	2	-1
2	Lack of consultant professionals experience	5	1	1	4	4	0
3	Poor design quality due to lack of finance	4	1	4	3	0	-3
4	Improper design and designs not done by the respective professionals	1	6	3	-5	-2	3
5	Lack of coordination between architectural, structural, electrical and sanitary professionals during the design	3	5	1	-2	2	4
6	Design without proper site investigation/soil test	2	4	6	-2	-4	-2
			Σd_{ij}^2		67	44	39
			r_s		-0.91	-0.26	-0.11

Proper design

A better design can get rid of workmanship defects and help to avoid the defects. Inadequately worded specifications and uncertain designs always cause low construction quality. In addition, a well-prepared design and drawing affects the future works to become easier and the defects can be identified and rectified more effectively.

Therefore, to be a good design, it will pass through design evaluation process, good coordination between different specialties, standardization by preparing design check lists and control the flow of information to minimize errors must be necessary.

Strict supervision

For good quality of construction;

i. Supervisors must have enough knowledge, skill and ability to inspect and to give decisions.
ii. Regular supervision must be important to prevent workmanship problems.
iii. The subcontractors or main contractors also need to carry out daily supervision of their workers.

Provide training and education

In order to have a good quality of construction, it is essential to have a good training and experience from the related field. This is because they will have the knowledge from the related field if they go through the training and programmes that will benefit them. In addition to upgrading knowledge, continuous training on the site will be important for all construction parties including the clients to share and minimize the construction defects.

Table 12. Testing the significance of correlation of defects related to design quality.

Ranking		Consultant	Client	Contractor
	r_S	1	-0.91	-0.26
Consultant	Critical r_S	-	0.886	0.886
	Significance	-	Significant	Not significant
	r_S	-0.91	1	-0.11
Client	Critical r_S	0.886	-	0.886
	Significance	Significant	-	Not significant
	r_S	-0.26	-0.11	1
Contractor	Critical r_S	0.886	0.886	-
	Significance	Not significant	Not significant	-

Table 13. Spearman rank correlation coefficient of ranking of consultant, client, and contractor for defects related to the construction process and its control.

S/N	Factor	Consultant rank (1)	Client rank (2)	Contractor rank (3)	Difference in ranking		
					d_{12}	d_{13}	d_{23}
1	Shortage of construction equipment	5	1	3	4	2	-2
2	Lack of proper consultant supervision	7	4	2	3	5	2
3	Lack of consultant timely respond and proper solutions	5	2	1	3	4	1
4	Delay of payment for the contractor	1	5	3	-4	-2	2
5	Delay of payment for consultant	2	3	6	-1	-4	-3
6	Weak communication between construction parties	3	6	7	-3	-4	-1
7	An incompetent team of contractor	3	7	3	-4	0	4
			Σd_{ij}^2		76	81	39
			r_s		-0.36	-0.45	0.3

Table 14. Testing the significance of correlation of defects related to the construction process and its control.

Ranking		Consultant	Client	Contractor
	r_S	1	-0.36	-0.45
Consultant	Critical r_S	-	0.786	0.786
	Significance	-	Not significant	Not significant
	r_S	-0.36	1	0.3
Client	Critical r_S	0.786	-	0.786
	Significance	Not significant	-	Not significant
	r_S	-0.45	0.3	1
Contractor	Critical r_S	0.786	0.786	-
	Significance	Not significant	Not significant	-

Proper communication among parties

Communication is very important in the construction siteto deliver a message or information from one person to another. If there are no communications, there will be no management. Therefore, it is important to let the workers understand when the supervisors are trying to deliver a message or information to them. Therefore, a proper communication between individuals and organizations including clients with environmental effects in vertical and horizontal levels in every office are essential in order to improve the quality of design, workmanship and construction by delivering correct information and message.

Proper construction management

Proper construction management would enhance the workmanship quality in construction. The capability of construction managers to manage, arrange and lead the work would affect the construction labor productivity. If a construction manager fails to lead and control the construction project, the quality problems may arise. Thus, a proper construction management is very crucial for every construction project.

Proper manpower management

Manpower management in terms of amount and quality of skilled workers is an important determinant of contractor performance and extremely prioritized by employers. Allocation of manpower in a construction site will affect the quality of the buildings. This is because less skilled and insufficient manpower will cause the work to be done in a rush manner and therefore, the quality will be affected. Likewise, a project with sufficient skilled manpower will eventually produce a good quality of the project. The allocation and management of manpower in the projects need to be arranged skillfully so that defects can be minimized.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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