Reducing defects in construction project

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Abstract— *Construction defect can be known as a problem in the construction industry that could cause the value of a building decrease eventually. Those defects incur a big cost & it is defined as the value of resource consumption for rework as a consequence of a defect. The causes of these construction defects are either because of poor design, or low quality workmanship, or because the building was not constructed according to the design, or because it has been subject to factors not allowed for in the design or poor supervision. So, the focus of this research was to investigate different types of construction defects in general and causes & effects of construction defects in particular and finally providing procedures which can reduce their occurrence.*

Keywords— ***Construction defect, workmanship, design, poor supervision***

1. INTRODUCTION

A construction industry can be known as major productive sector since the construction started in 1990s with development of projects. However the qualities of the certain construction project in Sangli are not always meet satisfaction. Construction defects are always the key concern of the construction industry. Different constructed facilities generate different types of defect and demand different levels and types of quality, depending on the function, system types and material used.

Defect works can be described as work which fails to comply with the express description or requirements of the contract, including very importantly any drawings or specifications, together with any implied terms as to its quality, workmanship, performance design. In the context of defective buildings, the major stumbling block in majority of cases is the recovery of the costs of rectification of defects, which are discovered before physical damage occurs.

This loss, which is the cost of repair, lost profits or diminution in value of the building, is classified as "Pure economic loss". Therefore, in those problematic circumstances, the researcher is interested to conduct a study on the type, cause and strategies of minimizing the defect in building construction project using a questionnaire survey and the data to be analyzed to meet the objectives of study.

2. METHODOLOGY-

2.1 QUESTIONNAIRE USED IN THE RESEARCH

The methodology used for this study was using case study and questionnaire. For case study checklist having 74 factors, 70 types of construction defects and 4 causes of construction defect, was developed. Then thorough site visit was done on selected seven building. For survey study a questionnaire of 91 factors was carefully designed from literatures conducted in building construction projects. It was organized in the form of a priority scaling (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree and 1 = not important, 2 = less important, 3 = moderately important, 4 = important, and 5 = very significant).

2.2 QUESTIONNAIRE DESIGN

From literature review it has been discussed about types, causes, effects & reducing measures of construction defects in building projects in various city around the country and at intervals of time, but not all of these types, causes, effects & reducing measures of construction defects in Residential Building Projects in Sangli, so it has been selected factors that has an impact in Sangli projects.

The questionnaire questions 70 types of construction defect, 4 causes of construction defect, 8 effects of construction defect and 13 defect reducing measures. The respondents were asked to fill the questionnaire and they were assured that the information will be confidential and used only for research purpose only.

The questionnaire included four parts that are related to types, causes, effects & reducing measures of construction defects in Residential construction projects, these parts are respondent profile, types and cause of construction defect, effect of construction defect and defect reducing measures.

Table 3.2: - Scales that represent level of agreement

Chances Of occurrenc	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Scale	5	4	3	2	1

Table 3.3: - Scales that represent level importance

Chances of occurrenc	Very Importan	Importan	Moderatel Importan	Less Importar	Not Importan
Scale	5	4	3	2	1

2.3 QUESTIONNAIRE USED IN THE RESEARCH

The methodology used for this study was using case study and questionnaire. For case study checklist having 74 factors, 70 types of construction defects and 4 causes of construction defect, was developed. Then thorough site visit was done on selected seven building. For survey study a questionnaire of 91 factors was carefully designed from literatures conducted in building construction projects. It was organized in the form of a priority scaling (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree and 1 = not important, 2 = less important, 3 = moderately important, 4 = important, and 5 = very significant).

The procedure used in analyzing the results aimed at establishing the mean score of the various parameters of construction defects. The score for each factor is calculated by summing up scores assigned to it by respondents. Therefore, the level of importance as indicated by the client & end users, contractors and consultants were used to measure the mean score of each factor.

The mean score (MS) for each variables of construction defect was computed by using the following formula;

***Msi = Σ (f*s)/N* ……………………………………………………** Equation 3.1

Where; *s* = score given to each type, effect & reducing measure of construction defect by respondents;

f = frequency of responses to each type, effect & reducing measure of construction defect;

N = total number of responses in the respective type, effect & reducing measure of construction defect.

Weighted Average was calculated by using the following formula;

Weighted Avg. = waxa+ wbxb+ wcxc…………………………… Equation 3.2

Where; *w*= relative weight (%)

x= mean score

a, b & c represent client & end users, contractor and consultant respectively

The Spearman (rho) rank correlation coefficient was used for measuring the differences in ranking between two groups of respondents scoring for various factors (i.e. clients versus consultants, clients versus contractors, and consultants versus contractors).

The Spearman (rho) rank correlation coefficient for any two groups of ranking is given by the following formula [28].

$$\text{Rho } (\rho cal) = 1 - \frac{6 \times (\Sigma d_i^2)}{N \times (N^2 - 1)} \quad \text{………… Equation 3.3}$$

Where:

Rho (ρcal) – Spearman rank correlation coefficient

di– The difference in ranking between respondent for each factors

N– Number of factors (variables)

Procedure for hypothesis testing:

1. Define the null hypothesis (H0) and the alternative hypothesis (HA)
2. Choose a value for ρ. (i.e. choose the significance level)
3. Calculate the value of the test statistic, Rho (ρcal).
4. Compare the calculated value with a table of the critical values of the test statistic.
5. If the calculated value of the test statistic is less than the critical value from the table, accept the null hypothesis (H0). If the absolute (calculated) value of the test statistic is greater than or equal to the critical value from the table, reject the null hypothesis (H0) and accept the alternative hypothesis (HA).

This was used to check the level of agreement between different groups of respondent during assigning score for different factors of the questionnaire. This was clearly mentioned on the analysis part of the research.

2.4 RESPONDENT PROFILE

Four items were prepared for obtaining information about respondents‟ organization such as the name of organization, company type (client, consultant or contractor) and respondents‟ job position.

2.5 TYPES AND CAUSES OF CONSTRUCTION DEFECT

This part of questionnaire consist of 8 categories related to types of construction defect, the categories included 70 types of construction defect, these categories are Foundation related defect; Basement, Beams, Column & Slab related defect;

Ceilings, walls, floors, doors and windows related defect; Roof related defect; Water supply system related defect; Electrical system related defect; Fire system related defect; Lift & Escalator related defect; Air condition/Heating system related defect. (The questionnaire is included in annex 1).

2.6 EFFECTS OF CONSTRUCTION DEFECT

This part illustrates the effects of construction defects in building construction project, these factors are the harvest of previous studies and literatures written in similar areas. A total of 8 factors were included in this part.

2.7 CONSTRUCTION DEFECT REDUCING MEASURES

This part illustrates construction defect reducing measures in building construction projects, and similar to effects of construction defect these factors were the harvest of previous studies and literatures written in similar areas. A total of 13 factors were included in this part.

- **TYPE OF RESPONDENT'S ORGANIZATION**

In this study, 47.61% (10) owners & end users, 28.57 % (06) contractors and 23.80 % (05) consultants participated in the questionnaire; method of selection was addressed in chapter three. The general response rate for contractors, owners and consultants was 70.00 % and the total numbers of respondents for the three parties were 21 out of 30 expected respondents. The response rate of contractors were 71.42 % (10 out of 14 respondent), for the owners & end users 75 % (06 out of 08 respondents) and 62.50 % (05 out of 08 respondents) for consultants.

Table 2.1: - Respondent organization

Name of Respondent Company	Questionnaire Distributed	Questionnaire Returned	Response Rate
Client and End users	14	10	71.42%
Contractor	08	06	75.00 %
Consultant	08	05	62.50 %

- **RESPONDENTS JOB POSITIONS**

Table 2.1 shows that 80.00 % (08) of clients & end users respondents were site engineers and 20 % (02) was project manager. It has been found that 33.33 % (02) of contractors respondents were project managers, 66.66 % (04) were site engineers. It has been found that 80.00 % (04) of the consultants respondents were resident engineers, 20 % (1) was assistant resident engineer. Totally out of 21 respondents of the three parties, 57.14 % (12) of the respondents were site engineers, 19.04 % (04) were resident engineers, 19.04 % (04) were projects managers and 4.76 % (1) was assistant resident engineer.

Table 2.2: - Respondent job position

Respondents job positions	Client and End users	Contractor	Consultant
Resident engineer	--	--	04
Project manager	02	02	--
Assistant resident engineer	--	--	01
Site engineer	08	04	--

Table 2.3: - Causes of defect from client & end users, consultant & contractor point of view

Causes of defect	Client and End users (%)	Contractor (%)	Consultant (%)	Overall Analysis
Design error	17.66	11.94	16.08	15.23
Workmanship error	49.50	52.40	54.39	52.10
Defective material	30.84	32.00	29.18	30.67
Poor subsurface investigation	1.99	3.64	3.48	3.04

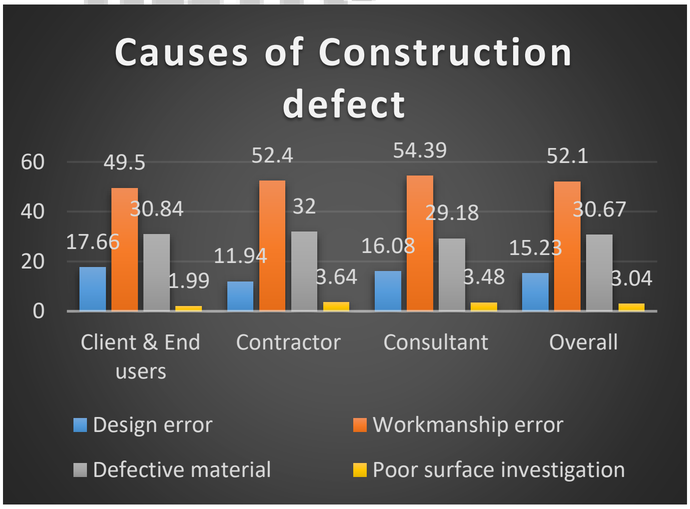

Fig 1 – Causes of construction defects

Tests for Agreements on Types, Effects and Reducing measures of Construction Defect Among Stakeholders in the Construction Industry

One of the purposes of this paper is to investigate whether there is an agreement or not on the attitudes of stakeholders towards the types, effects & reducing measures of construction defects in Residential Building Projects in Sangli. Hence in this section respondents response will be tested for correlation using Spearman rank correlation coefficients, to see if there is difference in ranking between two groups of respondents; these are Clients & End users versus Contractors; Contractors versus Consultants; and Clients & End users versus Consultants, on the different variables of construction defect and their rate of occurrence.

The purpose of a hypothesis test is to avoid being deceived by chance occurrences. The tests also helped to evaluate whether consensus of opinions exist among respondents.

The Null Hypothesis (HO) is: -There is no agreement in the ranking of types, effect & reducing measures of construction defects between two groups of respondents.

The Alternative Hypothesis (HA) is: -There is agreement in the ranking of types, effect & reducing measures of construction defects between two groups of respondents.

The spearman correlation coefficient (ρ) is calculated using Equation 3.3 and tabulated as shown below in Table 4.9

In order to decide whether to accept or reject the null hypothesis, the level of significance 95% (P = 0.05) is used. This allows to state whether or not there is "agreement" between respondents response.

If the calculated value of ρ is greater than the critical value, H0 is rejected, i.e. there is evidence of a statistically significant agreement between the groups. If the calculated value of ρ is less than the critical value, H0 is accepted**,** i.e. there is no evidence of a statistically significant agreement between the two groups.

Table 2.4: - Summary of correlation test on the ranking of types of construction defects

Respondents	**Rho (ρcal) = 1- 6*(Σdi2)** N*(N2- 1)	**Critical value of ρ (Appendix B)**	**Significance for P < 0.05**
Client & end user Vs. Contractor	**0.315**	**0.209**	significant reject
Client & end user Vs. Consultant	**0.550**	**0.209**	significant reject
Contractor Vs. Consultant	**0.454**	**0.209**	significant reject

In this case, with a significance level of 95% (P = 0.05), the calculated value of ρ for the all group cases are greater than the critical values of ρ, so the hypothesis that there is no significant agreement between the respondents is rejected i.e. the null hypothesis is rejected.

From table 4.9 above, it can be concluded that there is strong correlation between the attitudes of clients & end users and contractors, clients & end users and consultants and Contractors and consultanthence the null hypothesis should be rejected. This means that the respondents on these groups have the same perception about types of construction defects.

Table 2.5: - Summary of correlation test on the ranking of effects of construction defects

Respondents	**Rho (ρcal) = 1- 6*(Σdi2) N*(N2- 1)**	**Critical value of ρ (Appendix B)**	**Significance for P < 0.05**
Client & end users Vs. Contractor	**0.928**	**0.6429**	significant reject
Client & end users Vs. Consultant	**0.523**	**0.6429**	significant reject
Contractor Vs. Consultant	**0.750**	**0.6429**	significant reject

In this case, with a significance level of 95% (P = 0.05), the calculated value of ρ for the all group cases are greater than the critical values of ρ, so the hypothesis that there is no significant agreement between the respondents is rejected i.e. the null hypothesis is rejected.

From table 4.10 above, it can be concluded that there is strong correlation between the attitudes of clients & end users and contractors, clients & end users and consultants, contractors and consultants and hence the null hypothesis should be rejected. This means that the respondents on these groups have the same perception about effects of construction defects. This means that clients & end users and contractors, clients & end users and consultants, contractors and consultants have same perception about effects of construction defects.

Table 2.6: - Summary of correlation test on the ranking of defect reducing measures

Respondents	**Rho (ρcal) = 1- 6*(Σdi2)** N*(N2- 1)	**Critical value of ρ (Appendix B)**	**Significance for P < 0.05**
Client & end users Vs. Contractor	**0.719**	**0.4825**	significant reject
Client & end users Vs. Consultant	**0.203**	**0.4825**	significant Accepted
Contractor Vs. Consultant	**0.340**	**0.4825**	Significant Accepted

In this case, with a significance level of 95% (P = 0.05), the calculated value of ρ for the first group cases are greater than the critical values of ρ, so the hypothesis that there is no significant agreement between the respondents is rejected i.e. the null hypothesis is rejected & for last two group case the calculated value of p less than the critical value of p, so the hypothesis that there is no significant agreement between the respondents is accepted i.e. the null hypothesis is accepted.

From table 4.11 above, it can be concluded that there is strong correlation between the attitudes of clients & end users and contractors hence the null hypothesis should be rejected and the alternative hypothesis shall be accepted. This means that the respondents on these groups have the same perception about reducing measures of construction defects. It can also be concluded that there is no correlation between the attitudes of contractors and consultants, clients & end users and consultants and hence the null hypothesis should be accepted. This means that Contractor and Consultant & Client end user and consultant have different perception about reducing measures of construction defects.

Similarly, results of both studies agree on causes of construction defects which were accordingly the majority of construction defect in building projects were caused by poor workmanship. The factors contribute to poor workmanship are:

- poor project management,
- complicated role of subcontractor,
- lack of experience and competency of labor,
- language barrier to communication and lack of communication,
- unsuitable construction equipment,
- poor weather condition,
- limited time and limited cost, etc.
- Similarly measures that can reduce workmanship quality problem are:
- regular and periodic construction site supervision,
- training and education,
- proper communication among parties involved,
- proper construction management,
- proper manpower management and proper design,

And as the result of the analysis the most important measure to reduce occurrence of construction defect is periodic and regular construction site supervision that is also reducing measure to poor workmanship construction. Daily supervision should be carried out by the contractors or subcontractors and resident engineer so that workmanship problem can be identified and the remedy work can be executed immediately. Besides, when executing the supervision, contractor supervisory staff must possess the knowledge, expertise, and capabilities to administer the construction work.

3. CONCLUSION:

It can be concluded that there are various most effective strategies of minimizing the defect in building construction project are improve workmanship quality, all parties take responsibilities, frequent progress meeting, select the good quality of the materials, use modern construction method, improve ability to read and understand drawings, compliance with specification, do proper inspection, improve quality control and improve oversight in inspection. It is expected that by the better understanding regarding of the type, cause and strategies of minimizing defect in building construction project in Sangli. It will be to predict the upcoming construction project scenario. It is hope that this research can contribute to more understanding on construction defect issues that might be faced by contractor in Sangli. In line with the objective, it helps to increase the awareness of Sangli contractors towards managing and minimizing the defect work. By doing this, contractor will bring up construction industry into the next level of managing construction project effectively and efficiently.

4. RECOMMENDATIONS

The following points are recommended to all parties in order to reduce occurrence of construction defects in building projects.

- Majority of construction defects occurred because of poor workmanship. So, skilled, semi-skilled and unskilled laborers shall be trained on regular basis on stages of construction in general and on method of construction, required quality level of workmanship and quality of material in particular.
- Material supplier shall provide the right material as per the specification and contractor have the responsibility to check the quality at the time of delivery and engineers shall approve each material type before installing. This chain can reduce occurrence of construction defects caused by defective materials.
- Designers should be aware that they have share on the cause of construction defects and should up-to-date their design with the new technology and method of construction. Designer shall receive feedbacks from concerned parties of the project.

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