QUALITY MANAGEMENT PRACTICES IN GONDRANG-PULCHOWK SIX-LANE ROAD UPGRADING PROJECT AT CHITWAN DISTRICT, NEPAL

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ABSTRACT

The objective of this study is to assess the current quality management practices, determine the factors affecting quality management and to find out remedial measures that will improve the quality management practices in Gondrang-Pulchowk six-lane road construction project.

This research methodology is based on interviews and questionnaires survey with clients and contractors who were involved in the project as well as experts from related field. Statistical tools, relative importance index, validity and reliability tests, Spearman's correlation tests were used for the ranking of different quality aspects.

From the comparative study, it was found that most guidelines of the General Conditions of Contract, Special Specifications and Quality Assurance Plan of the contract document were met during project execution although few concerns of safety and correspondence remain to be addressed.

From the questionnaire survey, it was found that the practices to achieve quality need to be improved. Contractors consider cost factors as major factor affecting quality in the project whereas lack of supervision by contractors is cited by the clients as major factor affecting quality. To overcome the challenges of quality, proper material selection and usage, inspection, quality training, setting up quality department are seen as remedial measures. Improving safety at site, maintaining written correspondence, incorporating elements of ISO, proper selection and usage of materials, holding quality trainings and setting up quality control department are recommended for this project.

1. INTRODUCTION

Battikha (2003) states that in development, nonconformance happens when the completed condition of a task, or potentially its parts, strays from laid out prerequisites, and expects choices to be made in regards to their acknowledgment as well as correction and quality-related issues during development can be extended on the working existence of the completed venture. To the worker for hire, nonconformance can yield punishments, as well as cost and time loads for modify,
which can change over into efficiency misfortune. Quality is concern that is why people also search like ecofriendly construction and focus on every aspects even different provisions of fire found to be applied along with skill labour to assure quality construction Mishra and Shrestha (2017), Mishra and Rai (2017), Maskey and Mishra (2018).

Because of expanding pattern of government use in development work, the development area naturally helps up. In any case, development firms in Nepal are dealing with persistent issue remembering horrible showing for quality, terrible showing of time and cost, development squander, unfortunate efficiency and over ward of unfamiliar worker for hire and the specialists. Low quality execution is one of the basic issues among all Kusi et.al (2018), Chiluwal and Mishra (2018), Chiluwal and Mishra (2018), Chiluwal and Mishra (2017).

Mishra (2018) points that in the construction field of Nepal, quality is a major issue and emphasis is primarily given to it but in actual field it is not achieved to the level of expectation so it has become a matter of talk only Mishra et al. (2020), Khadka et al. (2021), Mishra et al. (2022).

A pilot project, Upgrading and Improvement of Gondrang-Pulchowk Section of East West Highway, Bharatpur is a six-lane road project in Chitwan district estimated to be completed in February 8, 2023 with the expenditure of NRs. 1,124,545,349.78 under the procurement, supervision and monitoring of Road Division Bharatpur. The project of high importance as it is the first six-lane project in the district of Chitwan with huge amount of cost involved.

Gondrang-Pulchowk road section of Bharatpur is a part of the nation’s important highway viz. East-West highway or Mahendra Highway. Narayanghat East section of road caters Average Annual Daily Traffic (AADT) of 36952 PCU as of 2020/21. Each year, millions of rupees are spent in the road maintenance of this section from Road Division Bharatpur office Department of Roads. (2021), Adhikari et al. (2022).

2. STATEMENT OF PROBLEMS

Construction industry has been widely criticized for its low quality of delivery of construction projects. The performance level of construction firms in Nepal is poor in delivering construction quality Mishra (2020).

In fiscal year 2077/78 alone, 57 crores rupees was spent for maintenance purpose of roads under Road Division Bharatpur office Department of Roads. (2021). The maintenance of a project can be saved if proper quality control measures are taken at the time of preconstruction, construction and post construction phase Kasula et al. (2017).

Gondrang-Pulchowk six-lane is a pilot project of Chitwan being constructed by a national contractor without the provision of any consultant. Kusi et al. (2018) point that it is important to enhance Nepalese contractor in implementing quality management in the construction and make them enthusiastic in enhancing quality in construction. Thus, it is necessary to take a proactive approach to study the quality aspects of this project as it is the first project of its scale and nature within Chitwan district. Recently the budget gap of development of Nepal is serious attention and quality construction material may be one option for the same Mishra and Aithal (2021). Mishra and Chaudhary (2018) also focus on cement handling behavior for quality conformation.
Hence, the researcher intends to explore as to what formal measures are being
taken and consequently identify the additional necessary measures needed to
ensure the quality in this six-lane project and other future projects of this scale and
nature. The paper is aimed to assess the current quality management practices in
gondrang-palchowk six-lane road upgrading project at Chitwan district of Nepal.

3. METHODOLOGY
3.1. RESEARCH DESIGN

3.2. RESEARCH APPROACH
The research approach adopted in this study comprises of a mixed research
approach defined as an inquiry into a quality management problem, based on
answering certain questions. This research involves a survey approach from which
statistical data were collected to answer questions in respect of the main subject of
study. Questionnaires are the main instruments used for this research.

3.3. STUDY AREA
Gondrang-Pulchowk project is located between Narayani bridge of
Narayanghat and the beginning of Tikauli forest of the East-West highway. The area
includes heavy to medium settlement areas, hospitals, and commercial centers. The
road stretches to 6080 meters and has features like expressway, median, drain,
service lanes, footpath, and a few culverts as well.
3.4. POPULATION AND SAMPLE

The major stakeholders of this projects are client and contractor. They are selected as respondents for the survey as they are the front-runners of the project execution. As no consultants are appointed for this project, they are not included in the study.

For the questionnaire survey, the population means all the technical personnel of client and contractor (Division Chief/Engineers/Sub-engineers) involved in the construction of Gondrang-Pulchowk six-lane project. The population size is small, so all population size is adopted as sample size through census method. Response rate is one hundred percent.
Table 1

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Categories</th>
<th>Clients</th>
<th>Contractors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Project Manager</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Contract Manager</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Engineers</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Sub-engineers</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Laboratory officers and assistants</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Supervisors</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><strong>Sub-Total</strong></td>
<td><strong>20</strong></td>
<td><strong>11</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>31</strong></td>
<td></td>
</tr>
</tbody>
</table>

3.5. DATA COMPILATION AND ANALYSIS

3.5.1. PRIMARY DATA

The major techniques of primary data collection are:

**Questionnaire**

An interview checklist was developed to collect people’s perception, understanding and view regarding the quality management aspect of the road project. It was done by census method. The questionnaire is divided into four main parts.

**Part I** is related with which practices for quality management system are adopted in the road construction projects.

- Practices for quality management system adopted in the road construction projects.
- Compliance check of standards.
- Practices for achieving quality on projects.
- Ranking of twenty elements of ISO standard.

**Part II** include the list of factors affecting quality management in road construction and responsible parties for ensuring quality assurance practices are:

- Factors affecting quality management in road construction.

**Part III** is related to the immediate practical improvements relevant to Nepal that could be implemented by projects for improving quality of works. Several reference were taken such as Adenuga (2013), Arditi (1998), Burati et al. (1992), Battikha (2003), Chin et al. (2011), Jha et al. (2007), Mishra et al. (2020), Khadka et al. (2021).

**Key Informant Interview**

Key Informant Interviews (KII) were conducted to the experts of the construction field and for primary data collection.

3.5.2. SECONDARY DATA

The secondary data was collected from the following sources:

1) Standard Specifications of Roads and Bridges, published by DoR
2) Quality control documents maintained by clients and contractors
3) Quality assurance plan (QAP) of this project
4) Laboratory test reports
5) Websites and online portals
6) Previous conducted research works available in nec-cps library
7) Published and unpublished literature

3.6. QUESTIONNAIRE DESIGN

The questionnaire was based on current quality practices, factors affecting quality in the project and remedial measures for quality improvement for Gondrang-Pulchowk six-lane road project.

The questionnaire was developed to gather the perception of client’s personnel and contractor’s personnel. The questionnaire was divided into following sections for meeting that purpose:

Part I: General data collection
Part II
Set I: Practices for achieving quality in this project
Set II: Ranking of ISO elements being followed in this project
Set III: Factors affecting quality of this project
Set IV: Remedial measures for quality improvement for this project

3.7. DATA ANALYSIS

The data obtained from the questionnaire survey was analyzed based on the ranking of responses of client, contractor, and overall ranking. Based on this ranking obtained from statistical analysis, the current quality management practices, factors affecting quality in construction and remedial measure to combat challenges of quality of this project were analysed.

3.8. VALIDITY AND RELIABILITY OF RESEARCH TOOLS

Legitimacy of Examination

Legitimacy estimates the level of arrangement of the outcomes or ends removed from the exploration poll with this present reality. Legitimacy alludes to how much an instrument estimates what it should gauge Polit and Hungler (1995). High legitimacy is the shortfall of efficient mistakes in the estimating instrument. At the point when an instrument is legitimate, it genuinely mirrors the idea it should quantify Wood and Haber (1998).

The questionnaire set was based on Likert’s scale. A similar type of questionnaire was also used and the use of RII was also previously used in similar nature of research by in the research carried out by Adhikari et al. (2022) and Mishra and Jha (2019). Most results of previous researches were in agreement with the findings made from the analysis of questionnaire survey in this study. The questionnaire were prepared with the help of literature review, concerned engineers, officers of DoR and approved in consultation with the supervisor for the validity and suitability to serve the purpose of the research.
3.9. CRONBACH'S ALPHA FOR RELIABILITY OF QUESTIONNAIRE

Reliability refers to the consistency of the scores. Lesser the consistency within a given measurement, lesser will be the usefulness of the data for analysis Ritter (2010). Cronbach’s alpha was developed by Cronbach in 1951. According to Ritter (2010) cronbach's alpha is one of the most commonly used reliability coefficient. It was developed based on the necessity to evaluate items scored in multiple answer categories. Formula for calculating Cronbach’s alpha is mentioned below:

\[
\alpha = \frac{K}{(K-1)} \times [1-\left(\frac{\sum \sigma_k^2}{\sigma_{total}^2}\right)]
\]

where,

- \(K\) is the number of items
- \(\sum \sigma_k^2\) is the sum of the \(k\) item score variances
- \(\sigma_{total}^2\) is the variance of scores on the total measurement

It is interpreted based on the level of reliability as follows:

- 0 to 0.19 = less reliable
- 0.2 to 0.39 = rather reliable
- 0.4 to 0.59 = quite reliable
- 0.6 to 0.79 = reliable
- 0.8 to 1.0 = very reliable

<table>
<thead>
<tr>
<th>S. N</th>
<th>Description of section</th>
<th>Cronbach's Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Quality method</td>
<td>0.755</td>
</tr>
<tr>
<td>II</td>
<td>Practices for achieving quality</td>
<td>0.854</td>
</tr>
<tr>
<td>III</td>
<td>Ranking of ISO9000 elements</td>
<td>0.841</td>
</tr>
<tr>
<td>IV</td>
<td>Factors affecting quality in the project</td>
<td>0.692</td>
</tr>
</tbody>
</table>

The values of Cronbach’s alpha for reliability test can be seen in the table above. The questionnaires imported from the distributed hardcopies were analysed in the excel sheet. As we obtained the result of Cronbach’s alpha to be above 0.6 for every sections in the research, the data from questionnaire is considered to be reliable based on the aforementioned theory.

3.10. STATISTICAL TOOLS USED FOR DATA PROCESSING

The general significance record technique (RII) was utilized in this to decide proprietors’, and workers for hire’s view of the overall significance of the distinguished presentation factors. The RII will be registered as

\[
RII = \sum \frac{W}{A \times N}
\]

The RII plans to assess the evaluations of the respondents. This approach is suggested in the past examinations Olusegun (2011) as proper logical way to deal with bunches rating of the variable in a given set. The examination included the
calculation of RII, which is agent rating point for the aggregate rating made for every variable in the subset. Utilizing the accompanying condition the overall significance record of each sub factor is determined as:

Where,

\[ W_i = \text{The rating given to each factor by the respondents going from 1-4} \]
\[ N = \text{All out no. of respondent} \]
\[ A = \text{Enormous rating score from respondent} \]

### 3.10.1. SPEARMANN’S RANK ORDER CORRELATION

As indicated by Glen (2013), Spearmann’s connection coefficient is factual proportion of the strength of a monotonic relationship among matched information. It really intends that in the event that one variable increments (or diminishes), the other one likewise increments (or diminishes). It is meant by \( r_{so} \) basically \( r \) and is compelled as \(-1 \leq r \leq 1\). Recipe for computing Spearmann’s position request connection is referenced beneath:

\[
\rho = 1 - \frac{6 \sum d_i^2}{n(n^2-1)}
\]

Where,

\( d_i = \text{difference between ranks between two paired data.} \)
\( n = \text{number of data.} \)

It is interpreted based on the strength of correlation as follows:

-1 = a perfect negative correlation between ranks
0 = no correlation between ranks
0 to 0.19 = very weak
0.2 to 0.39 = weak
0.4 to 0.59 = moderate
0.6 to 0.79 = strong
0.8 to 1.0 = very strong

+1 = a perfect positive correlation between ranks

Furthermore, spearmann’s rank order correlation was conducted for hypothesis testing to check the strength of monotonic relationship between the client’s and contractor’s view in each section as well as comparison of combined view in each section by formulating the null and alternative hypothesis. The details of testing are in the chapter four.

### 4. METHODOLOGY

#### 4.1. RESEARCH PHILOSOPHY

##### 4.1.1. QUALITY MANAGEMENT PRACTICES IN THE SIX-LANE ROAD PROJECT

The quality management practices of the project were analyzed based on questionnaire survey with project managers, engineers, sub-engineers, laboratory officers and supervisors along with interview with the project managers and engineers of clients and contractors to check the compliance of contract specification and guidelines.
4.1.2. PRACTICES FOR ACHIEVING QUALITY IN SIX-LANE PROJECT CONSTRUCTION

Questionnaire survey was carried out with clients and contractors to find out quality management practices adopted for achieving quality in the six-lane project.

Table 3

<table>
<thead>
<tr>
<th>Item</th>
<th>Practices</th>
<th>Clients RII</th>
<th>Clients Rank</th>
<th>Contractors RII</th>
<th>Contractors Rank</th>
<th>Overall RII</th>
<th>Overall Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Procurement of equipment and material</td>
<td>0.763</td>
<td>4</td>
<td>0.977</td>
<td>1</td>
<td>0.87</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Management commitment and involvement</td>
<td>0.775</td>
<td>3</td>
<td>0.932</td>
<td>3</td>
<td>0.853</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Work improvement teams</td>
<td>0.75</td>
<td>5</td>
<td>0.955</td>
<td>2</td>
<td>0.852</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Benchmarking</td>
<td>0.813</td>
<td>1</td>
<td>0.886</td>
<td>4</td>
<td>0.849</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Measurement of Outcomes</td>
<td>0.788</td>
<td>2</td>
<td>0.841</td>
<td>5</td>
<td>0.814</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>Recorded outcomes and achievements</td>
<td>0.75</td>
<td>5</td>
<td>0.75</td>
<td>8</td>
<td>0.75</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>Innovation and creativity</td>
<td>0.688</td>
<td>9</td>
<td>0.773</td>
<td>6</td>
<td>0.73</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>Training and Education in quality</td>
<td>0.75</td>
<td>5</td>
<td>0.614</td>
<td>12</td>
<td>0.682</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>Safe Work Procedures (SWPs)</td>
<td>0.725</td>
<td>8</td>
<td>0.636</td>
<td>10</td>
<td>0.681</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>Reward System/Incentives</td>
<td>0.675</td>
<td>10</td>
<td>0.636</td>
<td>10</td>
<td>0.656</td>
<td>10</td>
</tr>
<tr>
<td>11</td>
<td>Profitability</td>
<td>0.438</td>
<td>11</td>
<td>0.773</td>
<td>6</td>
<td>0.605</td>
<td>11</td>
</tr>
<tr>
<td>12</td>
<td>Designer ISO9000 series certification</td>
<td>0.375</td>
<td>13</td>
<td>0.705</td>
<td>9</td>
<td>0.54</td>
<td>12</td>
</tr>
<tr>
<td>13</td>
<td>Contractor ISO9000 series certification</td>
<td>0.425</td>
<td>12</td>
<td>0.591</td>
<td>13</td>
<td>0.508</td>
<td>13</td>
</tr>
</tbody>
</table>

Figure 4

Figure 4 RII of Practices in Achieving Quality in the Project
Client’s view

Table 4 shows that client’s personnel ranked “benchmarking” in the first position with RII of 0.813. Following this practice, “measurement of outcomes” is ranked second with an RII of 0.788. Similarly, “management involvement and commitment” is ranked third with an RII of 0.775. However, it is concluded from the analysis that “reward and incentives”, “profitability”, “Designer ISO9000 series certification” and “Contractor ISO9000 series certification” are not practiced in the project.

Contractor’s view

Table 4 shows that “procurement of equipment and material” is ranked first by the respondents of contractors with an RII of 0.977. Similarly, “work improvement teams” is ranked second with an RII of 0.955. Also, “management commitment and involvement” is ranked third with an RII of 0.932. This view is consistent with the client’s view. However, “training and education in quality” and “contractor’s ISO9000 certification” are not practiced by the contractors.

Combined view

Table 4 shows that the respondents ranked “procurement of materials and equipment” in the first position with RII of 0.87. It was followed by “management involvement and commitment” in the second position with an RII of 0.853. “Work improvement teams” was ranked third with an RII of 0.852. The respondents ranked “Designer ISO9000 series certification” and “Contractor ISO9000 series certification” as the least practiced methods in the project. This result was consistent with the findings of Mishra et al. (2020), Mishra (2018) in a similar research.

Spearmann’s ranked correlation coefficient (ρ) and P-value between Client’s and Contractor’s view on Section I

- Correlation between Client’s view and Contractor’s view

Spearmann’s ranked correlation is given by the formula:

\[ \rho = 1 - \frac{6 \sum d_i^2}{N(N^2-1)} \]

= 0.59

Where,

di = difference between ranks of two items of questionnaire

N = number of items of questionnaires = 13

From the above data, Spearmann’s ranked correlation is found to be 0.59 which shows moderate monotonic relationship between client’s view and contractor’s view.

Hypothesis testing and P-value for Client’s view and Contractor’s view:

1) Null Hypothesis (H0) = There is no monotonic relationship between the owner’s view and the contractor’s view (i.e. \( \rho = 0 \)) on the minimizing measures of claims and disputes in construction of medium sized hydropower projects.
2) Alternate Hypothesis (H1) = There is monotonic relationship between the owner's view and the contractor's view (i.e. $\rho \neq 0$) on the minimizing measures of claims and disputes in construction of medium sized hydropower projects.

3) Level of significance ($\alpha$) = 0.05

4) Critical value for 5% level of significance for two tailed test with degree of freedom (dof) 11 ($T_{\text{critical}}$) = 2.16

5) Calculated value of T-statistics = $\rho \times \sqrt{\frac{N-2}{1-\rho^2}}$ = 0.0338

6) Calculated P-value for dof 34 with above obtained T-statistics (P-value) = 0.0338

7) Result and decision: Here, P-value < $\alpha$, hence, reject the null hypothesis (H0) and accept the alternate hypothesis (H1). Therefore, it is concluded that there is monotonic relationship between the client's view and the contractor's view on practices carried out to achieve quality in the Gondrang-Pulchowk six-lane construction project.

4.1.3. RANKING OF THE TWENTY ELEMENTS OF ISO STANDARD IN SIX-LANE ROAD CONSTRUCTION

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Ranking of ISO elements Based on Practice in the Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>Element</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Inspection</td>
</tr>
<tr>
<td>2</td>
<td>Inspection and Test Status</td>
</tr>
<tr>
<td>3</td>
<td>Corrective and Preventive Action</td>
</tr>
<tr>
<td>4</td>
<td>Management Responsibility</td>
</tr>
<tr>
<td>5</td>
<td>Document and Data Control</td>
</tr>
<tr>
<td>6</td>
<td>Calibration</td>
</tr>
<tr>
<td>7</td>
<td>Control of Nonconforming Product</td>
</tr>
<tr>
<td>8</td>
<td>Quality System</td>
</tr>
<tr>
<td>9</td>
<td>Purchasing of materials</td>
</tr>
<tr>
<td>10</td>
<td>Process Control</td>
</tr>
<tr>
<td>11</td>
<td>Control of Quality Records</td>
</tr>
<tr>
<td>12</td>
<td>Contract Review</td>
</tr>
<tr>
<td>13</td>
<td>Handling, Storage, Packaging, Preservation and Delivery</td>
</tr>
<tr>
<td>14</td>
<td>Design Control</td>
</tr>
<tr>
<td>15</td>
<td>Control of Customer Supplied Product</td>
</tr>
<tr>
<td>16</td>
<td>Identification and Traceability</td>
</tr>
</tbody>
</table>
Table 5 shows that the respondents ranked “Inspection and test status”, “Inspection” and “Management responsibility” as the first, second and third most practiced ISO element with RII of 0.90, 0.875, 0.85 respectively. Similarly, “identification and traceability” and “internal quality audits” are the least practiced elements of ISO in this project.

**Contractor’s view**

Table 5 shows that the contractor’s respondents ranked “inspection” in first position. This result is consistent with the clients as well. Similarly, they ranked “corrective and preventive action” and “purchasing of materials” as second and third most practiced elements of ISO.

**Combined view**

Table 5 shows that the respondents ranked “Inspection”, “Inspection and test status” and “corrective and preventive action” as the three most practiced elements of ISO in this project. However, “internal quality audits” and “training” are ranked as the least practiced element of ISO within this project.

**Spearmann’s ranked correlation coefficient (ρ) and P-value between Client’s and Contractor’s view on Section II**

- **Correlation between Client’s view and Contractor’s view**

Spearmann’s ranked correlation is given by the formula:

Spearman’s rank correlation coefficient between client and contractor’s view
\[
(\rho) = 1 - \frac{6 \Sigma d_i^2}{N(N^2-1)}
\]
\[= 0.59\]

Where,
\[d_i = \text{difference between ranks of two items of questionnaire}\]
\[N = \text{number of items of questionnaires} = 20\]

From the above data, Spearman’s ranked correlation is found to be 0.59 which shows monotonic relationship between client’s view and contractor’s view.

**Hypothesis testing and P-value for Client’s view and Contractor’s view:**

1) Null Hypothesis (H0) = There is no monotonic relationship between the owner’s view and the contractor’s view (i.e. \(\rho = 0\)) on the minimizing measures of claims and disputes in construction of medium sized hydropower projects.

2) Alternate Hypothesis (H1) = There is monotonic relationship between the owner’s view and the contractor’s view (i.e. \(\rho \neq 0\)) on the minimizing measures of claims and disputes in construction of medium sized hydropower projects.

3) Level of significance (\(\alpha\)) = 0.05

4) Critical value for 5% level of significance for two tailed test with degree of freedom (dof) 11 (\(T_{\text{critical}}\)) = 2.10

5) Calculated value of T-statistics = \(\rho \times \frac{\sqrt{N-2}}{\sqrt{1-\rho^2}}\)
\[= 3.1002\]

6) Calculated P-value for dof 34 with above obtained T-statistics (P-value) = 0.0058

7) Result and decision: Here, P-value < \(\alpha\), hence, reject the null hypothesis (H0) and accept the alternate hypothesis (H1). Therefore, it is concluded that there is monotonic relationship between the client’s view and the contractor’s view on practices carried out to achieve quality in the Gondrang-Pulchowk six-lane construction project.

### 4.1.4. COMPLIANCE CHECK OF STANDARDS AND QAP

A detailed compliance check with the technical specification of the contract document of this project was carried out. A comparison of standards against execution was made along with interview with the project manager of client and contractor to gather an idea whether the requirements of special specification and approved QAP are met during the execution of this project. The provisions of conditions of contract, special specifications and QAP of the contract of this project were as follows

The technical specification is a part of contract document of this project. It has two parts:

1) Section A – covers technical specification for quality control, workmanship, materials, and equipment involved in the construction and it is the same as Standard Specifications for Road and Bridge Work 2073.

2) Section B – covers special provisions to standard specifications to suite major items of work contained in the BoQ.
It was also noted that in the contract document provisions that, if there is any discrepancy between standard and special specification, special specifications shall prevail.

The special specifications require the following specifications to be met:

1) **Traffic Management Provisions**
   - A Traffic Management Plan TMP must be submitted to the client. It includes traffic control equipment, signage, traffic closure plans, lane closure plan, traffic diversion plan, etc.
   - Preparation of Traffic Guidance Scheme
     This is also covered by BoQ is lump sum.

2) **Survey and Setting Out**
   This part of contract document requires the contractor to supply the client SMARTROAD survey design and data.

3) **Maintenance of the Road**
   The contractor is required to perform maintenance works to keep the site in working condition to the satisfaction of the client. They are required to follow "Road Maintenance Manual" and employ length workers who are working in the routine maintenance of the project road.
   
   The compensation for this item is also covered in the BoQ of this project.

4) **Contractor’s Establishment on Site Office, Equipment Testing Facilities, etc**
   As per the contract document, it the responsibility of the contractor to acquire land for the storage and testing facilities/equipment.

5) **Source Approval of Materials**
   This requires the contractor to select sources of the materials and present it to the client before the materials are used on the site. The samples should be taken and tested in the presence of the client before approval and the client reserves the right to accept or reject the materials based on quality control tests performed.

6) **Site Safety**
   It is stated that the contractor should follow established rules and regulations of all safety matters in the site. During construction, the contractor must erect, maintain and subsequently remove barricades, guides, lighting, sheeting, shoring, temporary sidewalks, temporary covering of potential accident areas. All open excavations, high voltage power lines shall be protected sufficiently to keep out livestock and ensure safety of workmen and public. It is also stated that the contractor is responsible for all damages and injury caused by trespassing.

7) **Field Laboratory**
   The contract document requires the contractor to furnish complete lab facilities including furniture, fittings, equipments, vehicles, manpower, etc. and to be managed and operated by the contractors under the general supervision of the client. It should include but not limit field density test, concrete cube mould, compaction apparatus, sieve for gradation tests etc. Quality control engineer (QCE) is to be provisioned who is accountable to the employer and shall work under the site engineer.
It was found that there is a provision of "provisional sum for supply and hiring of NDT and lab equipment to carry out additional tests for material and works as required and instructed by the project manager" in the contract.

However, there is no separate quality control department established within the road office.

4.1.4.1. SETTING TIME OF CEMENT

According to the Standard Specification of Roads and Bridges 2073, setting time: initial setting time min 45 minutes and final setting time max. 600 minutes. During Key Informative Interview, it was found that SSRB and IS guidelines are followed while performing laboratory tests.

<table>
<thead>
<tr>
<th>Table 5 Setting Time of Cement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
</tr>
<tr>
<td>Cement</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

The setting time test of cement was taken from secondary data and the result was found coherent to specifications. It was found that average initial setting time and final setting time of cement is 230 min. and 328 min. respectively, the initial and final setting time of cement was found that within road specification and standard guideline.

4.1.4.2. QUALITY OF SAND

Table 6 Testing of Sand Quality

<table>
<thead>
<tr>
<th>Sieve Size (mm)</th>
<th>Specification limit</th>
<th>Actual Result</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.75</td>
<td>100</td>
<td>100</td>
<td>Ok</td>
</tr>
<tr>
<td>2.36</td>
<td>90</td>
<td>95.12</td>
<td>Ok</td>
</tr>
<tr>
<td>1.18</td>
<td>70</td>
<td>82.24</td>
<td>Ok</td>
</tr>
<tr>
<td>0.6</td>
<td>40</td>
<td>56.78</td>
<td>Ok</td>
</tr>
<tr>
<td>0.3</td>
<td>5</td>
<td>46</td>
<td>Ok</td>
</tr>
<tr>
<td>0.15</td>
<td>0</td>
<td>8.78</td>
<td>Ok</td>
</tr>
<tr>
<td>0.075</td>
<td>0</td>
<td>1.13</td>
<td>Ok</td>
</tr>
<tr>
<td>Pan</td>
<td></td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

While testing the gradation of sand used in the project via sieve analysis, it was found that the sand used is within the specification limit as per IS: 2386 (Part III) - 1963. The quality of sand is thus not questionable.

4.1.4.3. QUALITY OF AGGREGATES

According to the guidelines of SSRB and IS, it was mentioned about the properties like gradation, AIV, flakiness index that should be tested at various stages of construction.
Table 7

<table>
<thead>
<tr>
<th>Material</th>
<th>Physical Properties</th>
<th>General Guidelines</th>
<th>Actual</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate</td>
<td>Flakiness index</td>
<td>&lt;25%</td>
<td>21%</td>
<td>Ok</td>
</tr>
<tr>
<td></td>
<td>AIV value</td>
<td>&lt;40%</td>
<td>20.49%</td>
<td>Ok</td>
</tr>
<tr>
<td>Gradation</td>
<td>Sieve size</td>
<td>Min.  Max.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>100 100</td>
<td></td>
<td>Ok</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>90   100</td>
<td></td>
<td>90.82</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>25   35</td>
<td></td>
<td>26.81</td>
</tr>
<tr>
<td></td>
<td>4.75</td>
<td>0    10</td>
<td></td>
<td>0.82</td>
</tr>
</tbody>
</table>

While testing the aggregates, it was found to be within the specification limits as in table 4.14. Thus, the aggregates used at the site were sound enough to carry on the further works Mishra and Chaudhary (2018), Mishra et al. (2021), Aryal and Mishra (2020).

4.1.4.4. QUALITY OF CONCRETE

Upon compressive strength test of concrete for M25 concrete being used in slab culvert, it was found that the target compressive strength is met by the standards.

Table 8

<table>
<thead>
<tr>
<th>Specification Limits</th>
<th>Actual Value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 days 28 days</td>
<td>16.6 N/mm² 25 N/mm²</td>
<td>Ok</td>
</tr>
<tr>
<td>7 days 28 days</td>
<td>18.70 N/mm² 28.75N/mm²</td>
<td>Ok</td>
</tr>
</tbody>
</table>

4.1.4.5. QUALITY OF FINE AGGREGATE IN CONCRETE

Upon testing the gradation of sand used for concreting purpose by sieve analysis, it was reported that the gradation of sand lies within the specification envelope provided by the guidelines as in the Appendix. So, the use of such sand is not objectionable.

Table 9

<table>
<thead>
<tr>
<th>Sieve Size (mm)</th>
<th>Specification Limit</th>
<th>Actual result</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>100</td>
<td>100</td>
<td>Ok</td>
</tr>
<tr>
<td>4.75</td>
<td>90</td>
<td>95.01</td>
<td>Ok</td>
</tr>
<tr>
<td>2.36</td>
<td>75</td>
<td>85.29</td>
<td>Ok</td>
</tr>
<tr>
<td>1.18</td>
<td>55</td>
<td>69.77</td>
<td>Ok</td>
</tr>
<tr>
<td>0.6</td>
<td>35</td>
<td>51.85</td>
<td>Ok</td>
</tr>
<tr>
<td>0.3</td>
<td>8</td>
<td>27.9</td>
<td>Ok</td>
</tr>
<tr>
<td>0.15</td>
<td>0</td>
<td>9.82</td>
<td>Ok</td>
</tr>
<tr>
<td>0.075</td>
<td>0</td>
<td>3.94</td>
<td>Ok</td>
</tr>
<tr>
<td>Pan</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.2. FACTORS AFFECTING QUALITY MANAGEMENT IN SIX-LANE CONSTRUCTION

**Table 10**

<table>
<thead>
<tr>
<th>Item</th>
<th>Factors</th>
<th>Client</th>
<th>Contractor</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lack of Quality training/meeting</td>
<td>0.913 2</td>
<td>0.886 6</td>
<td>0.899 1</td>
</tr>
<tr>
<td>2</td>
<td>Escalation of material prices</td>
<td>0.763 10</td>
<td>0.932 3</td>
<td>0.847 2</td>
</tr>
<tr>
<td>3</td>
<td>Difficult data collection system</td>
<td>0.8 8</td>
<td>0.886 6</td>
<td>0.843 3</td>
</tr>
<tr>
<td>4</td>
<td>Material and equipment cost</td>
<td>0.7 19</td>
<td>0.977 1</td>
<td>0.839 4</td>
</tr>
<tr>
<td>5</td>
<td>Project Environment</td>
<td>0.763 10</td>
<td>0.909 4</td>
<td>0.836 5</td>
</tr>
<tr>
<td>6</td>
<td>Project labor cost</td>
<td>0.713 17</td>
<td>0.955 2</td>
<td>0.834 6</td>
</tr>
<tr>
<td>7</td>
<td>Liquidity of organization</td>
<td>0.725 14</td>
<td>0.909 4</td>
<td>0.817 7</td>
</tr>
<tr>
<td>8</td>
<td>Lack of motivation</td>
<td>0.9 3</td>
<td>0.705 10</td>
<td>0.802 8</td>
</tr>
<tr>
<td>9</td>
<td>Lack of quality policy</td>
<td>0.725 14</td>
<td>0.818 8</td>
<td>0.772 9</td>
</tr>
<tr>
<td>10</td>
<td>Poor relationship and partnering among project participants</td>
<td>0.9 3</td>
<td>0.636 14</td>
<td>0.768 10</td>
</tr>
<tr>
<td>11</td>
<td>Low quality and poor availability of resources</td>
<td>0.813 6</td>
<td>0.682 11</td>
<td>0.747 11</td>
</tr>
<tr>
<td>12</td>
<td>Bureaucracy</td>
<td>0.688 21</td>
<td>0.75 9</td>
<td>0.719 12</td>
</tr>
<tr>
<td>13</td>
<td>Poor Training system</td>
<td>0.838 5</td>
<td>0.545 20</td>
<td>0.691 13</td>
</tr>
<tr>
<td>14</td>
<td>Lack of process improvement</td>
<td>0.784 9</td>
<td>0.591 16</td>
<td>0.688 14</td>
</tr>
<tr>
<td>15</td>
<td>Employee attitudes</td>
<td>0.738 12</td>
<td>0.614 15</td>
<td>0.676 15</td>
</tr>
<tr>
<td>16</td>
<td>Nature uniqueness</td>
<td>0.663 23</td>
<td>0.659 12</td>
<td>0.661 16</td>
</tr>
<tr>
<td>17</td>
<td>Incompatible tendering procedures</td>
<td>0.725 14</td>
<td>0.568 18</td>
<td>0.647 17</td>
</tr>
<tr>
<td>18</td>
<td>Lack of Management commitment</td>
<td>0.625 24</td>
<td>0.659 12</td>
<td>0.642 18</td>
</tr>
<tr>
<td>19</td>
<td>Lack of contractor supervision</td>
<td>0.963 1</td>
<td>0.318 25</td>
<td>0.64 19</td>
</tr>
<tr>
<td>20</td>
<td>Low effective project management system</td>
<td>0.7 19</td>
<td>0.568 18</td>
<td>0.634 20</td>
</tr>
<tr>
<td>21</td>
<td>Lack of auditing system</td>
<td>0.738 12</td>
<td>0.523 21</td>
<td>0.63 21</td>
</tr>
<tr>
<td>22</td>
<td>Low tendency to teamwork</td>
<td>0.813 6</td>
<td>0.364 24</td>
<td>0.588 22</td>
</tr>
<tr>
<td>23</td>
<td>Unavailability of competent staff</td>
<td>0.675 22</td>
<td>0.5 22</td>
<td>0.588 22</td>
</tr>
<tr>
<td>24</td>
<td>Low quality drawing and specification</td>
<td>0.545 25</td>
<td>0.591 16</td>
<td>0.568 24</td>
</tr>
<tr>
<td>25</td>
<td>Inappropriate method of contractor</td>
<td>0.713 17</td>
<td>0.386 23</td>
<td>0.549 25</td>
</tr>
</tbody>
</table>

**Client’s view**

Table 10 shows that the client’s respondents ranked “Lack of contractor supervision”, “lack of quality training/meeting” and “lack of motivation” as the first, second and third factor affecting quality of this project with an RII of 0.963, 0.913 and 0.9 respectively. However, “low quality drawing and specification” is the least affecting factor with an RII of 0.713. The result indicates that contractor supervision is lacking in the project.

**Contractor’s view**

Table 10 shows that the contractor's respondents ranked “material and equipment cost”, “labor cost” and “escalation of prices” as the three most affecting factors with RII of 0.977, 0.955 and 0.932 respectively. The contractors responded
that the least affecting factor of quality is "lack of contractor supervision" with RII of 0.318. This result is not consistent at all with the client's view.

A KII was conducted with the experts of the related field to find out the reason of this inconsistency. According to KII, the following may be the reasons of the disagreement between client and contractors:

1) Cost factors are more important to contractors than to client.
2) Price escalation provision in contract may not be able to cover the actual inflation in the market.
3) Reduced responsibility of petty contractors who are hired by the contractor is also one of the factors affecting quality.
4) Pressure to complete the project within stipulated time can affect quality aspects.

**Spearmann’s ranked correlation coefficient (ρ) and P-value between Client’s and Contractor’s view on Section III**

- **Correlation between Client’s view and Contractor’s view**

Spearmann’s ranked correlation is given by the formula:

\[ \rho = 1 - \frac{6\sum d_i^2}{N(N^2-1)} \]

Where,
\[ d_i = \text{difference between ranks of two items of questionnaire} \]
\[ N = \text{number of items of questionnaires} = 13 \]

From the above data, Spearmann’s ranked correlation is found to be which shows no monotonic relationship between client’s view and contractor’s view.

**Hypothesis testing and P-value for Client’s view and Contractor’s view**

1) Null Hypothesis (H0) = There is no monotonic relationship between the client’s view and the contractor's view (i.e. \( \rho = 0 \)) on the minimizing measures of claims and disputes in construction of medium sized hydropower projects.
2) Alternate Hypothesis (H1) = There is monotonic relationship between the client’s view and the contractor's view (i.e. \( \rho \neq 0 \)) on the minimizing measures of claims and disputes in construction of medium sized hydropower projects.
3) Level of significance (α) = 0.05
4) Critical value for 5% level of significance for two tailed test with degree of freedom (dof) 11 (T critical) = 2.07
5) Calculated value of T-statistics = \( \rho \times \sqrt{N-2} \times \sqrt{1-\rho^2} \)
\[ = -0.3087 \]
6) Result and decision: Here, T-statistic< tabulated t, hence, accept the null hypothesis (H0) Therefore, it is concluded that there is no monotonic relationship between the client’s view and the contractor’s view on factors affecting quality in the Gondrang-Pulchowk six-lane construction project.
5. CONCLUSION

From the comparison of standard guidelines and field execution of works of this project, most standards are met but a few shortcomings are found. Routine maintenance works which are carried out in a cycle of three months requires shorter cycle as per site condition. A traffic guidance scheme is not prepared in detail as required by the specifications. Site safety owing to open excavation is still a major problem of this project. Complete digitization of documents is lacking from client’s end. Proper checklists for quality control need to be established. Procurement of equipment and material were perceived as major elements practised for achieving quality. Procurement of equipment and material, data and information, management commitment and involvement were found to be major within twenty elements of ISO standard used in the construction of six-lane road construction. Materials selection and usage along with the inspection and testing of executed works were major quality control method adopted in the six-lane road construction project.

CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS

The author is thankful to all the professionals who took part in discussions. The Author thanks to Nepal Engineering College.

REFERENCES


