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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.

Keywords: Quality, Road Construction, Quality Assurance Plan, Quality Management, Quality Improvement

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), Chilwal 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-pulchowk six-lane road upgrading project at Chitwan district of Nepal.

3. METHODOLOGY

3.1. RESEARCH DESIGN

Figure 1

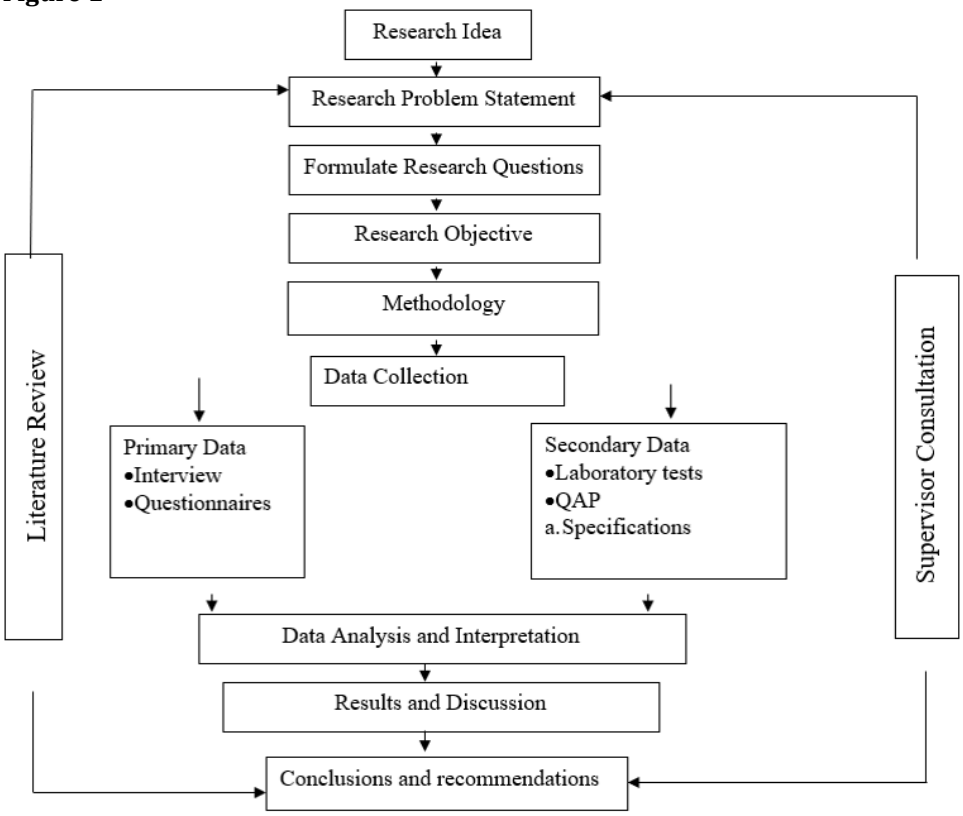

Figure 1 Research Design Flowchart

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.

Figure 2

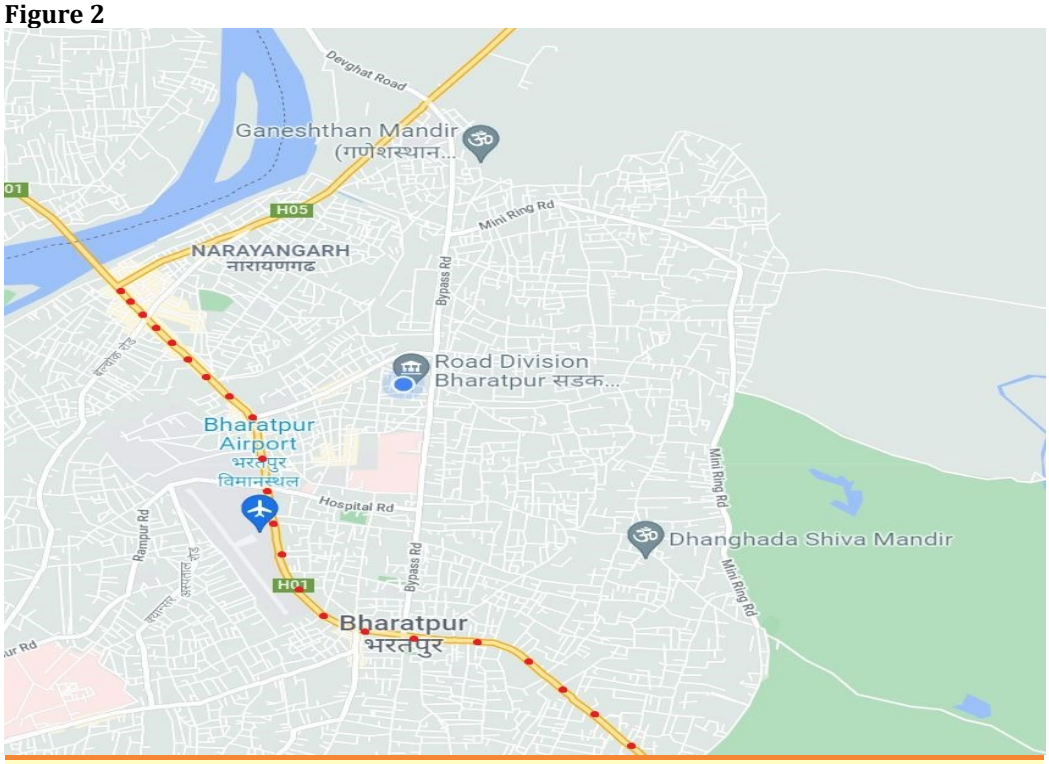

Figure 2 Project Location (maps.google.com)

Figure 3

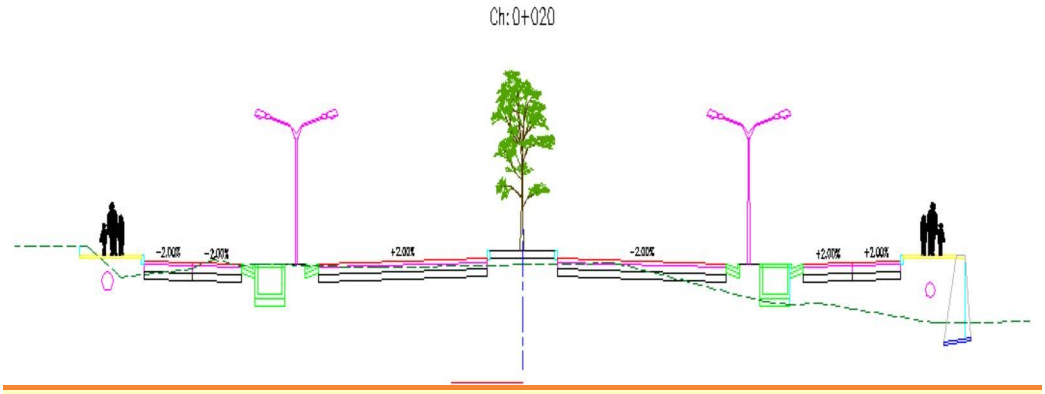

Figure 3 Typical Cross-Section of the Project

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 1 Respondents of the survey

S.N.	Categories	Respondents	
		Clients	Contractors
1	Project Manager	1	1
2	Contract Manager	0	1
2	Engineers	4	4
3	Sub-engineers	9	2
4	Laboratory officers and assistants	2	1
5	Supervisors	4	2
	Sub-Total	**20**	**11**
	Total	**31**	

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:

$\alpha = K/(K-1) * [1-(\Sigma\sigma k 2 / \sigma total 2)]$

where,

K is the number of items

$\Sigma\sigma$ k 2 is the sum of the k item score variances

σtotal 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 2

Table 2 Cronbach's Alpha Value for Reliability Test

S. N	Description of section	Cronbach's Alpha
I	Quality method	0.755
II	Practices for achieving quality	0.854
III	Ranking of ISO9000 elements	0.841
IV	Factors affecting quality in the project	0.692

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

Cheung et al. (2004), Iyer and Jha (2005), Ugwu and Haupt (2007):

$$RII = \frac{\Sigma W}{A \times N}$$

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,

Wi= The rating Given to each factor by the respondents going from 1-4

N= All out no. of respondent

A= 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 rsor basically r and is compelled as - 1 ≤ r ≤ 1. Recipe for computing Spearmann's position request connection is referenced beneath:

$$\rho = \frac{1- 6*\Sigma di^2}{(n*(n^2-1))}$$

Where,

di= difference between ranks between two paired data.

n = 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 comparision 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 3 Practices for Achieving Quality in the Project

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

Figure 4

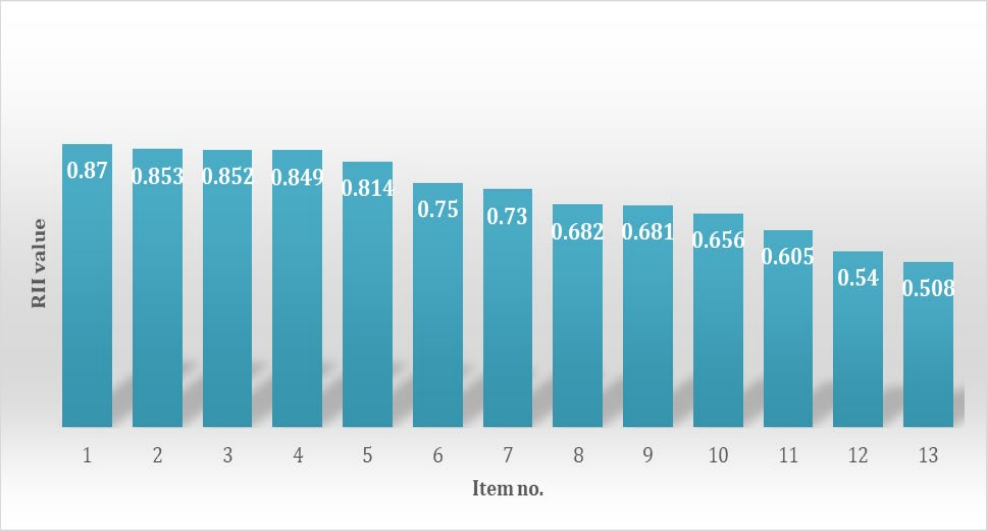

Figure 4 RII of Practices in Achieving Quality in the Project

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:

Spearman's rank correlation coefficient between client and contractor's view

$$(\rho) = 1 - \frac{6\Sigma di^2}{N(N2-1)}$$

$$= 0.59$$

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. ρ = 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 (α) = 0.05
4) Critical value for 5% level of significance for two tailed test with degree of freedom (dof) 11 (T critical) = 2.16
5) Calculated value of T-statistics = $\rho \times \frac{\sqrt{N-2}}{\sqrt{1-\rho 2}}$ = 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 < α, 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 4

Table 4 Ranking of ISO elements Based on Practice in the Project

Item	Element	Clients		Contractors		Overall	
		RII	Rank	RII	Rank	RII	Rank
1	Inspection	0.875	2	0.955	1	0.91	1
2	Inspection and Test Status	0.9	1	0.909	4	0.9	2
3	Corrective and Preventive Action	0.825	4	0.932	2	0.88	3
4	Management Responsibility	0.85	3	0.841	7	0.85	4
5	Document and Data Control	0.788	5	0.886	6	0.84	5
6	Calibration	0.725	10	0.909	4	0.82	6
7	Control of Nonconforming Product	0.775	6	0.841	7	0.81	7
8	Quality System	0.738	9	0.841	7	0.79	8
9	Purchasing of materials	0.625	15	0.932	2	0.78	9
10	Process Control	0.763	8	0.795	13	0.78	9
11	Control of Quality Records	0.713	11	0.841	7	0.78	9
12	Contract Review	0.688	13	0.841	7	0.76	12
13	Handling, Storage, Packaging, Preservation and Delivery	0.688	13	0.841	7	0.76	12
14	Design Control	0.775	6	0.659	17	0.72	14
15	Control of Customer Supplied Product	0.713	11	0.682	15	0.7	15
16	Identification and Traceability	0.588	20	0.75	14	0.67	16

17	Statistical Techniques	0.613	16	0.682	15	0.65	17
18	Servicing	0.6	17	0.659	17	0.63	18
19	Internal Quality Audits	0.6	17	0.614	19	0.61	19
20	Training	0.613	16	0.545	20	0.58	20

Figure 5

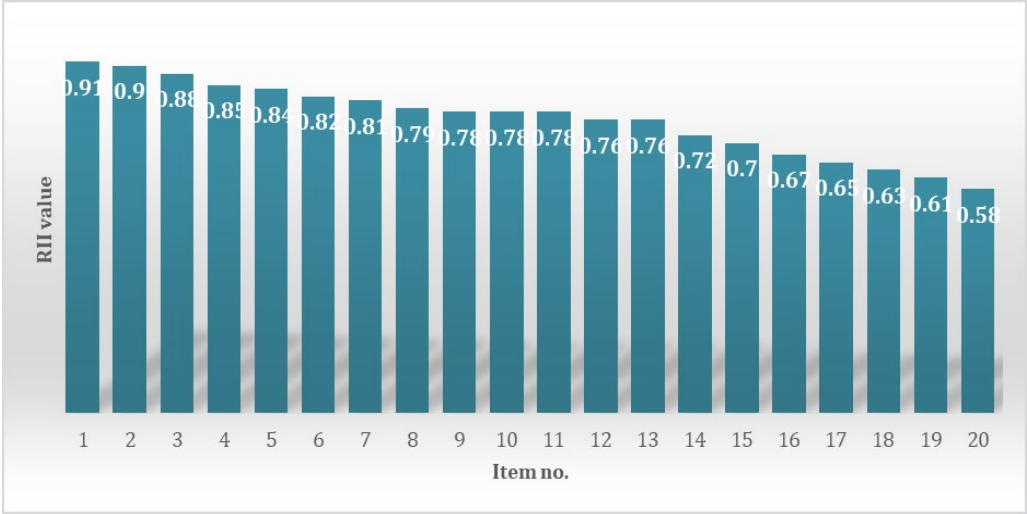

Figure 5 Ranking of ISO Elements Based on Practice in the Project.

Client's view

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

$$(\rho) = 1 - \frac{6\Sigma di^2}{N(N2-1)}$$

$$= 0.59$$

Where,

di = difference between ranks of two items of questionnaire

N = number of items of questionnaires = 20

From the above data, Spearmann'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 contractors 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 (α) = 0.05
4) Critical value for 5% level of significance for two tailed test with degree of freedom (dof) 11 (T 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 < α, 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 satisfactor 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 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 is 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 5

Table 5 Setting Time of Cement

Material	Physical properties	General Guidelines		Actual	Remarks
Cement	Setting time	Initial	> 45 min.	230 min	Ok
		Final	< 600 min.	328 min	Ok

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

Table 6 Testing of Sand Quality

Sieve Size (mm)	Specification limit		Actual Result	Remarks
4.75	100	100	100	Ok
2.36	90	100	95.12	Ok
1.18	70	100	82.24	Ok
0.6	40	100	56.78	Ok
0.3	5	70	46	Ok
0.15	0	15	8.78	Ok
0.075	0	5	1.13	Ok
Pan			0	

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 7 Test of Aggregates

Material	Physical Properties	General Guidelines			Actual	Remarks
Aggregate	Flakiness index	<25%			21%	Ok
	AIV value	<40%			20.49%	Ok
	Gradation	Sieve size	Min.	Max		
		40	100	100	100	Ok
		20	90	100	90.82	Ok
		10	25	35	26.81	Ok
		4.75	0	10	0.82	Ok

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 8 Test of Concrete Quality

Specification Limits		Actual Value		Remarks
7 days	28 days	7 days	28 days	
16.6 N/mm2	25 N/mm2	18.70 N/mm2	28.75N/mm2	Ok

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 9 Test of Fine Aggregates in Concrete

Sieve Size (mm)	Specification limit		Actual result	Remarks
10	100	100	100	Ok
4.75	90	100	95.01	Ok
2.36	75	100	85.29	Ok
1.18	55	90	69.77	Ok
0.6	35	59	51.85	Ok
0.3	8	30	27.9	Ok
0.15	0	10	9.82	Ok
0.075	0	5	3.94	Ok
Pan				

4.2. FACTORS AFFECTING QUALITY MANAGEMENT IN SIX-LANE CONSTRUCTION

Table 10

Table 10 Factors Affecting Quality in Construction of the Project

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

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:

Spearman's rank correlation coefficient between client and contractor's view

$$(\rho) = 1 - \frac{6\Sigma di^2}{N(N2-1)}$$

$$= -0.06$$

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 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. ρ = 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. ρ ≠ 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 = $\rho \times \frac{\sqrt{N-2}}{\sqrt{1-\rho 2}}$

   = -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.

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