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Original Article

Analysis of Cost Driven-Critical Clauses for EPC Contract: Indian National Highway Projects

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Abstract *- Disagreements, lawsuits, and litigation pertaining to the construction of national highways are growing daily on a global scale. Most of the studies have focused on problems with the creation of contracts and defective contract documents. Contractors file lawsuits against the government, citing issues such as design changes, delays, and additional costs. The disputes underscored the challenges in managing large-scale infrastructure projects. With rapidly rising infrastructure development in India, lots of disputes, arbitration, litigation, and court cases are available in the Indian construction sector. It becomes imperative to carefully review contract clauses to guarantee the timely execution of projects and their cost-effectiveness. This study is based on an analysis of cost-driven critical contract clauses for Engineering Procurement and Construction (EPC) model contracts of highway Projects in India that have a high risk of cost overrun, time overrun, and litigation. A qualitative approach has been used for the data collection from contractors, consultants, and National Highway Authority of India (NHAI) officials. A total of 161 responses were collected. Dimension reduction approach of Principal Component Analysis (PCA) was used to find out total variance, rotated component matrix, etc. The outcome shows that the EPC contracts contained multiple significant (high-risk) contract clauses related to time overruns, cost overruns, and lawsuits. The cost-driven critical clauses in decreasing order are as follows: supervision and monitoring during maintenance, traffic regulation, quality monitoring and supervision, and change in scope.*

Keywords *- Clauses, Contract, EPC, Litigation, Principal Component Analysis, NHAI, Time overrun.*

1. Introduction

Highway construction projects are notorious for their innate complexity [1]. High-value claims, arbitration cases, and project completion delays are all on the rise. Construction contracts are typically associated with delays and price increases. Inhibitors to production plague the industry on the one hand, while technological and procedural advancements are occurring quickly on the other side.

The construction sector is essential for sustaining a country's economic stability. Every country's socio-economic progress depends on its network of roads. The NHAI has made great strides in this regard. National highways are the primary thoroughfare for interstate movement of people and goods in the country. Currently, the nation's motorways and national highways are 1,44,634 km [2]. For the years 2023–2024, the Indian National Highway Authority established a goal of 13,000 kilometers. The NHAI is open to new advancements in technology, the green movement, and other areas. An electronic toll-collecting system utilizing radio frequency identification technology has received approval from the NHAI. To cut down on vehicle waiting time, Fastag technology has handled quick toll collection. The NHAI is also keeping an eye on how well the GPS-based toll collection system is working. Road construction by the NHAI is averaging 28 kilometers per day. The Indian Union Budget places a higher priority on the NHAI project. Improvements in planning and execution processes, the use of information technology, the use of aerial vehicles, and computerization of all aspects are the main areas of attention for NHAI [3].

An ideal contract should be a win-win situation for all the parties. Formulation of proper contract agreements is crucial for this objective as they help to overcome the resistance to change through either incentives or targeted coercion. There are different types of contracting models with their associated merits and demerits. An Engineering, procurement, and construction contract faces lots of potential problems. While drafting the construction contract less attention is generally put on the pre-construction stage phase of the project. The contractor would bear EPC contract design, procurement, and construction risk. The Ministry of Road Transport and Highway (MoRTH) has published a standard EPC agreement that applies to all the NHAI projects.

Every contract typically contains various clauses drafted with the overall aim of smooth execution of the project. But, these clauses, if not prepared properly, can often create disagreement among the associated parties. Surprisingly, provisions that were built with a specific goal to be considered also appear to act contrary to those precise goals at times [1]. Chan et al. observe the leading causes of lawsuits were uncertain contract terms, insufficient script, unequal application of clauses by dissimilar stakeholders, a shortage of genuine facts, and the nature of modification. They further said that the key causes of disagreement between stakeholders are inadequate credentials and inappropriate facts.

The contract and stakeholder categories in the suggested model contain these top-ranked classifications, which may be found in the literature and the Supreme Court of Canada (SCC). Additional expenses are incurred during a lawsuit for both the parties and the initial agreement [4]. The interpretation of the terms of building contracts, both in their language and spirit, is essential in the resolution of conflicts. Every word must be comprehended in its particular context as well as holistically if a topic is covered by multiple phrases that overlap to be understood. The use of indemnity contract provisions as a strategy to shift the risk associated with the engineering, construction, and architecture sectors will only become more intricate [5].

Kevin Walsh created rules regarding the utilization of idiomatic words in organizational norms. He designed and educated a reviewer whose job is to spot questionable language and notify the organization's decision-makers about it-identifying warning signs and essential provisions that need to be either avoided or included in every contract. Researchers also identify and gather the lessons learned from the company's mistakes [6]. When creating or modifying contract clauses, drafters and revisers must consider the criteria outlined they observe to ensure that project stakeholders can exploit Alternative Dispute Resolution (ADR) possibilities instead of pursuing legal action [1].

The top ten causes of delays are work in rainy times, overflow, impact on people's topography, choosing the lowest bidder for the project, regular machinery failures, insufficient skilled staff-project teams from contractors, unexpected terrain, delayed running payments, and tiny efficiency labor [7].

K.V. Prasad et al. observed that problems with utility-related delays and land acquisition were the main reasons for the delay of highway or transportation projects. They demonstrated causes, and the importance of causes for delays have different reasons. When determining the stoppage in the claim resolution through the initial contract process, the formation of reasonable terms of agreement, the project schedule, records, and formalities were examined [8]. The majority of delays and expense overruns were seen in major urban development projects. Only seven percent of the projects below reflection were finished in the budget, and up to eight and a half percent of them were completed as per the calendar [9].

Communal conflicts inside the project are more partial by the affected party in the society than by internal project interests [10]. The three input segments to disagreement prior to it influence a project lawfully. The first two segments of the claim process are the filing of the claim, claim rejection, and the third segment is the failure of a peaceful resolution. Claims arising from estimate overruns and delays in some project works eventually trigger legal action [11].

Parikh et al observed that time and money overruns were predicted from a series of replica builds up using the occurrence of claim source and captivating addicted to account for numerous claim causes operating simultaneously [12]. Disagreements concerning the advantages of the claim could exist. It is advised to develop claim administration and promote the application of more resourceful dispute curtail techniques by altering management awareness to expect, avert, or cater to prevalent difficulty areas [13].

Resolution of the dispute in construction consumes lots of time and money invested in the process each year. It's critical to implement the appropriate management plan in order to reduce claims and tackle issues [14]. Litigation, which used to be the first line of action when legal uncertainty did not satisfy the requirements, shall be tested for court review from the district court to the Supreme Court and the final verdict by the angry applicant.

The favorable option is arbitration because of its advantages over other options, including legal faith, expenditure, shorter duration, and secrecy of the whole procedure. Since most arbitration panel decisions are contested in court, it has gradually evolved into a last resort. [15] The thought of Alternative Dispute Resolution (ADR) may eventually supplant conventional dispute settlement procedures. If discussions or a compromise fail, ADR guarantees to address some concerns like legal, business-related, manufacturing, and citizens problems. ADR usually involves a neutral body that facilitates discussion and patches up disagreements among the stakeholders. ADR aims to maintain peace between individuals and lessen animosity between groups [16].

Alrasheed et al. observed that many arbitration-related issues are eventually settled through the legal system. Construction disputes in Kuwait do not appear to be significantly impacted by arbitration. Settlement does not look to include a noteworthy force on the project disagreement in Kuwait, as many disputes not settled in arbitration ultimately go to the court [17]. India offers a range of simultaneous dispute settlement methods. Dominant cause, apportionment,

and other internationally recognized approaches have been applied in India despite their relative youth and lack of widespread application [18].

Marko et al. present a dynamic model for contingency management that enables the simulation of the major stakeholders' influences over the process of managing a contingency budget. It also investigates the behavior of contingency accumulation and releases throughout a database project, specifically under the sequential phases of an EPC. It is recommended that the model be used as a communication tool between different stakeholders on policies in complicated situations like contingency release and decision influencing, in addition to serving as a simulation tool for contingency decision-making [19].

Most of the research was done for the overall budget, time overrun, cost overrun, pre-construction problem, construction dispute, etc. Many researchers have suggested different models for communication between parties, prediction models for claim analysis, alternative methods of dispute resolution, etc. Murli et al. used a Natural language processing extraction tool to detect exculpatory clauses in construction contracts.

Murli et al. suggested that reading contracts cannot be entirely replaced by artificial intelligence or machine learning [20]. Kevin Walsh had identified the threat created by knotty clauses in contracts by putting red flags on the contract clauses on the basis of their own knowledge [6]. The researcher had not taken any expert opinions from contractors, consultants, arbitrators, etc, and had not used any statistical methods to identify the problematic contract clauses for EPC in the construction of the highway. The rise of disputes, arbitration, and litigation ultimately causes court cases related to EPC contracts, which are available in different courts. Many contract clauses are critical (high-risk) for disputes, arbitration, and litigation.

This study restricted the cost parameter to evaluate as they are responsible for disputes and litigation of Indian highway projects. This study have main objective is to identify the cost-driven critical (high-risk) clauses of existing EPC contracts for Indian National Highways with the aid of principal component analysis as a statistical method by taking expert opinion.

2. Materials and Methods

The methodology adopted for this study is shown in Figure 1.

2.1. Data Collection

Records were collected through the questionnaire. The survey form was separated into two sections. The first section contains basic information about respondents like names, designation, demographic details, type of organization, experience, etc. At the same time, the second section had twenty-seven key questions with different parameters like time, cost, quality, safety, arbitration, and claim.

This paper discussed only for cost parameter. The opinion of respondents was taken on a Likert scale of 1 to 5, where 5 shows exceptionally high impact, 1 shows extremely low, 2 indicates low impact, 3 identified moderate effect, and 4 shows high impact. The respondent has to correlate the cost-driven contract clauses that cause litigation, time overruns, and cost overruns for each question. The mentioned questionnaire form is available in Figure 2.

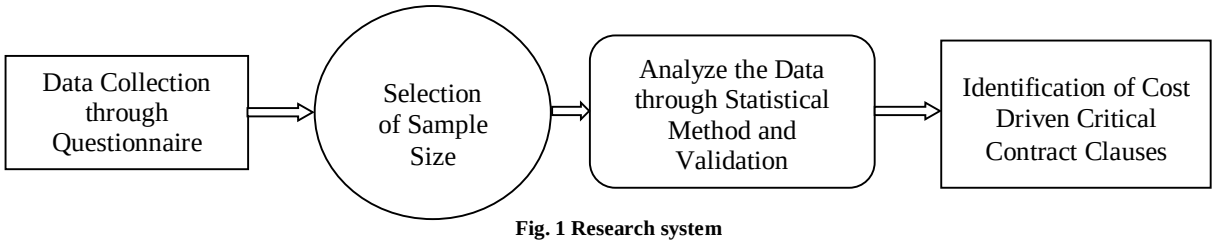

Fig. 1 Research system

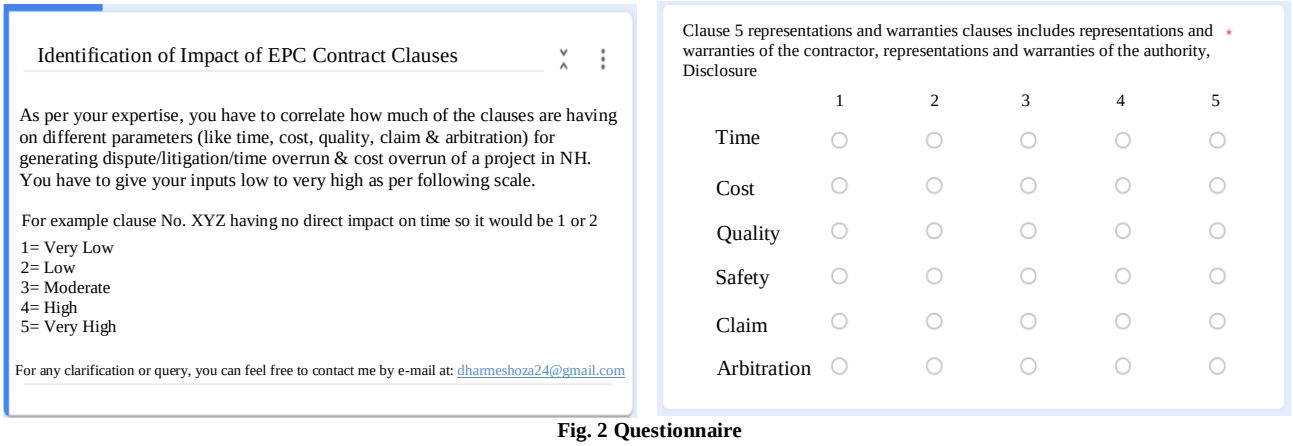

Fig. 2 Questionnaire

The questionnaire was sent to 285 experienced individuals who had EPC contract experience professionals for National Highway as an arbitrator, NHAI officers, contractors, consultants, and others working in India.

2.2. Selection of Sample Size

Sampling is the process of examining a portion of the whole data in order to find the important information within the more extensive collection of data. The area for this study was focused on the entire part of India with construction professionals. Lots of formulas with their merits and demerits were available for finding out the sampling size or population. This study's target sample was not known; the adopted sampling was non-probability. For this study, the formula adopted, which is given by Hair et al., is as below: The Estimating a size of sample for a proportion:

$$n = \frac{Z^2 * p * (1-p)}{E^2} \quad [21]$$

Where,

n = Size of the sample,

Z = Z score corresponding to the desired confidence level,

p = Estimated proportion of the population with a particular characteristic or response.

E = Level of precision

Considering,

Z = 1.96 for the confidence level of 95 %,

p = 50%,

E = 8% [22]

From the above formula and consideration of the above value the sample size n = 150 samples. For the study minimum of 150 responses are required.

2.3. Analysis of Data

There were lots of techniques and software available for analysis. The software Statistical Product and Service Solution was used for the study. This software could analyze the data with proper precaution. The collected records were examined in software as a dimension-reduction technique for focalization.

Graphing, data transformation, and direct marketing tools are all included in the software. In its main view of the software, data were filled the same as a spreadsheet. Although working with data is a complex and time-consuming task, this program can manage and analyze the data with ease, as shown in Figure 3. Principle component analysis was the method employed for analysis. PCA is a widely used technique for multidimensional information visualization, enhancing data interpretability while conserving maximum information and analyzing massive datasets with many dimensions or features per observation.

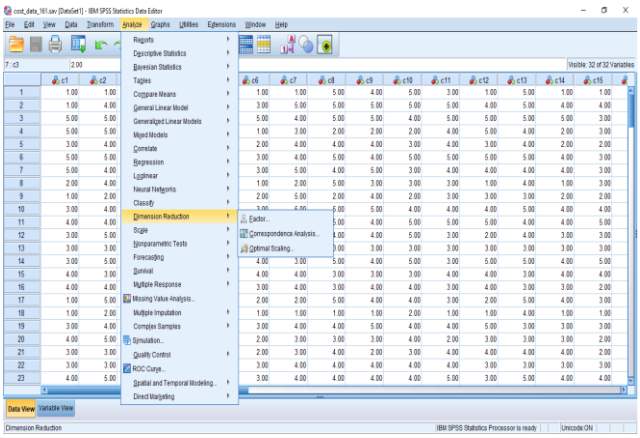

Fig. 3 Dimension reduction technique in software

PCA is a statistical method for lowering a dataset's dimensionality. It aids in the reduction of massive data sets' dimensions. Reducing the number of variables in records gathered inevitably degrades correctness, and the solution to reduction in dimension is in favor of ease.

With smaller data sets, mechanism culture algorithms can examine record spots much more rapidly and simply because there are few unnecessary variables to evaluate. The collected data in terms of a Likert scale of 1 to 5 were incorporated in the statistical software data window. The dimension reduction procedure was carried out step by step for validation of sample adequacy and other parameter.

To discover whether the records were suitable for factor analysis, the Kaiser-Meyer-Olkin (KMO) statistical test was performed. Kaiser-Meyer-Olkin test for sampling was obtained for sample adequacy. The KMO test was employed to evaluate the sampling's efficacy. If the KMO test result is more significant than 0.7, the adequacy sample was sufficient Bartlett sphericity test matches up to a pragmatic correlation matrix to the identity matrix. Test findings show multivariate normality and adequate sampling. If the worth value of Bartlett's test is less than 0.5, then the test is considered valid.

The Extraction method was selected as the principal component in statistical software, as shown in Figure 4. From the same tab, select the display screed plot and extract based on Eigenvalue. This study considered the value of components whose Eigenvalue is more than one. The number of factors to keep in an exploratory Factor Analysis (FA) or the number of principal components to keep in a Principal Component Analysis (PCA) can be determined using the screed plot.

Select the rotation factor analysis method as very max. Varimax was, without a doubt, the most widely used rotation technique. Each factor in a basic varimax solution had a significant number of zero weightage and a tiny number of heavy weightage.

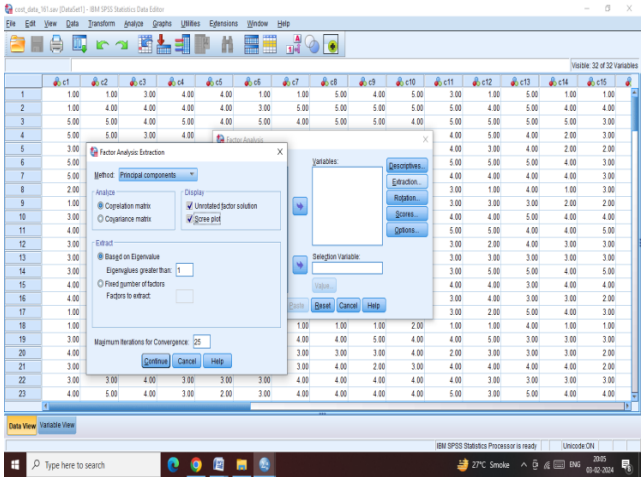

Fig. 4 Extraction method selection in software

Data were processed to find the rotating compound matrix. A rotating matrix is used to minimize the number of factors that have strong loadings on the variables being studied.

Data were further analyzed for overall variance and other information. Ultimately finding was obtained from the values of individual components from the rotated compound matrix. Sorting was done for the rotated component matrix from higher impact value to lower value. The correlation of value was done with the different clauses of the contract.

3. Results and Discussion

Out of 285 respondents who were given the questionnaire, 161 submitted their responses, as shown in Table 1. The percentage response was 56%, quite adequate for the construction sector. The collected response data were more than required as 150 no from the sample size equation calculated above. Nearly 40% of responses were given by the contractor as 65 no, which would be the highest response from the other type of response, as shown in Figure 5 overview of response data. Other follows, like 29% by consultants, 17% by NHAI officers, 8% by arbitrators, and 6% by other individuals as academicians. The respondent has two to thirty-six years of experience.

Table 1. Overview of the response data

Serial Number	Types of Respondents	Response in Number
1	Contractor	65
2	Arbitrator	12
3	NHAI officers	27
4	Consultant	47
5	Academicians	10
	Total	161

Responses were collected from all over the state of India as Andhra Pradesh, Assam, Bihar, Chattisgadh, Delhi, Gujarat, Goa, Haryana, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Tamilnadu, Telangana, Tripura, Uttar-Pradesh, and West Bengal. The highest responses were collected, 32 % from Gujarat, 16 % from Maharashtra, and less than 10% from other states.

PCA method is used to evaluate the information. Squeezing a massive gathered of inconsistencies into a slighter set that conserves most of the facts in the better set is the technique known as principal component analysis, and it helps to reduce the number of dimensions in massive data sets.

For analysis, SPSS software is utilized. Every piece of data was uploaded to the SPSS program. The KMO test was employed to evaluate the sampling's adequacy. The test result showed that the sampling adequacy was adequate because it was 0.905 larger than 0.7.

Bartlett's test was the next to be conducted, and it was deemed successful because the worth value was less than 0.5; the result is available in Table 2. Bartlett and Kaiser-Meyer-Olkin (KMO) sphericity test findings show multivariate normality and sufficient sample [23].

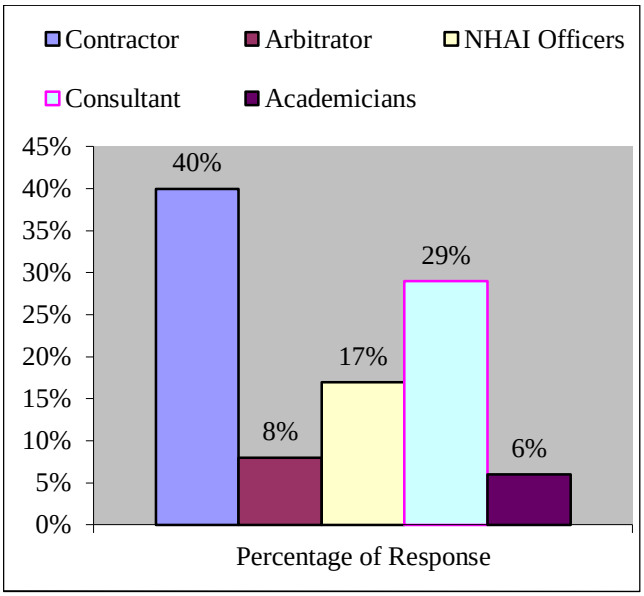

Fig. 5 percentages the response data

Table 2. Result of the KMO test

The KMO Sampling Adequacy Measure		0.905
Test of Bartlett's the Sphericity	**Chi-Square**	2255.354
	df	351
	Sig.	0.00

The screed plot is the plot that shows the total number of factorial components and the distance from other elements. Figure 6 shows that there were more considerable disparities for factors one and two, while other factors had some disparities. In this study, the component where more than one Eigenvalue is considered for further analysis. As per Figure 5, five components were discovered as their Eigenvalue is more than one. The details of all five components are shown in Table 3 and Figure 7.

The first component had 22 % of variance and the other four components were variance in decreasing order. It indicates that the first five components, which are present in the screed plot, have a variance of more than 61%. It was observed that the Eigenvalue was less than one from six to twenty-seven components, having the least percentage variance and most minor disparities.

In this study, it was neglected from the analysis because of the most negligible impact. The beauty of the dimension factor was to give an essential component. For further analysis in this study, statistical software was used to determine the data as a rotating component matrix. This component matrix contains the weighted factors of each component with its variables.

Table 4 shows the weighted factor of the five components, which was determined earlier. Each contract clause has an exclusive weighted factor value against each element. The five components contain the weighted factor values of all twenty-seven variables.

Out of twenty-seven clauses, numbers 17, 5, 20, 12, 7, 6, 25, 21, 4, 2 have zero weightage. While others had a different value as shown in Table 4. The highest value was 0.826 for the 15-number clause, while the lowest value was 0.604 for the 26-number clause.

The weighted component values of each variable were sorted from highest to lowest condition. Table 5 shows the sorted value with the contract clause. The four critical high-risk cost-driven contract clauses were 15, 16, 11, and 13, respectively. The mentioned clauses were at increased risk because the component value was higher.

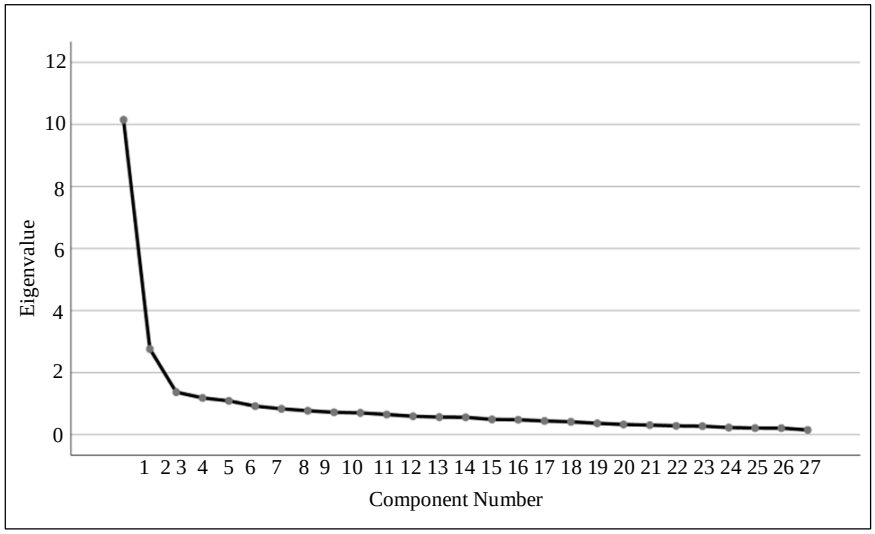

Fig. 6 Screed plot- components

Table 3. Details of the total variance

Component	Squared Loadings of the Rotated Sum		
	Sum	Percentage of Variance	Combined Percentage
1	5.992	22.192	22.192
2	4.030	14.926	37.117
3	3.081	11.409	48.527
4	2.179	8.069	56.596
5	1.266	4.689	61.285

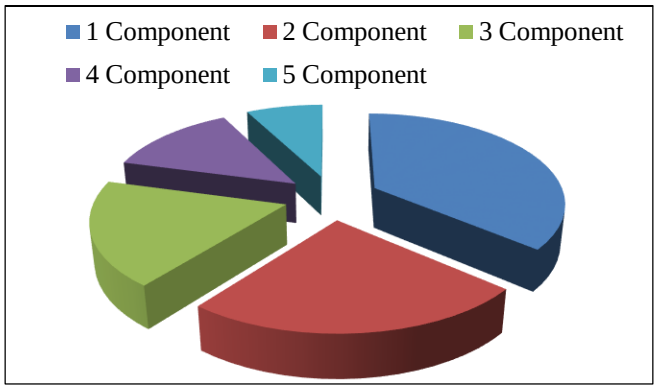

Fig. 7 Square loading of each component

Table 4. Rotated component matrixes

Cl No.	Component					Total
	1	2	3	4	5	
c15	0.826					0.826
c16	0.802					0.802
c11	0.768					0.768
c14	0.682					0.682
c18	0.635					0.635
c24	0.622					0.622
c17						0.000
c5						0.000
c20						0.000
c12						0.000
c7						0.000
c6						0.000
c13		0.757				0.757
c8		0.722				0.722
c9		0.662				0.662
c10		0.642				0.642
c19		0.621				0.621
c23			0.708			0.708
c27			0.668			0.668
c22			0.641			0.641
c26			0.604			0.604
c25						0.000
c21						0.000
c1				0.741		0.741
c4						0.000
c2						0.000
c3					0.662	0.662
Extra. Method: PCA						

Table 5. Overview of high-impacted clauses

Rank	Clause No.	Component Value	More Impacted Critical Contract Clauses
1	15	0.82	Supervision and Monitoring during Maintenance
2	16	0.80	Traffic Regulation
3	11	0.76	QA, Monitoring, and Supervision
4	13	0.75	Change of Scope

4. Conclusion

Identification of cost-driven critical-high-risk contract clauses is not an easy task as visualization. Critical contract clauses generate disputes, time delays, exceeding costs, litigation, and, ultimately, court cases. This research demonstrated the EPC contract clauses, which contain a criticality of court cases and have been influence throughout cost.

The questionnaire poll yielded 161 replies out of 285 in total, for dimension reduction data were evaluated by principal component analysis in statistical software. The conclusion explains the number of critical provisions in EPC contracts that would escort to litigation. The first cost-driven critical high-risk contract clause with a significant influence is supervision and monitoring during maintenance. The following three high-risk, cost-driven contract clauses are traffic regulation, quality assurance monitoring and supervision, and change of scope.

This study has provided insight into the high-risk cost-driven contract clause of the EPC contract of NHAI. The critical contract clause is a challenge for the practitioner. To minimize litigation, cost-driven, essential, and crucial clauses of the contract need to be revised and amended.

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