

# Evaluation of Disputes in Kerala Construction Industry



U. A. Devangana and Anu V. Thomas

**Abstract** Disputes are an inevitable part of the construction industry. Every year a huge amount of money and time is wasted on the settlement of disputes in construction projects. There can be different causes for the disputes to arise in construction projects. Prevention of disputes can be possible through proper identification and analysis of the factors causing them. This paper is a study on the identification of construction disputes from literature and through a questionnaire survey in Kerala public projects. The responses from the survey were logically analysed using fuzzy-DEMATEL analysis and Relative Importance Index (RII). Fuzzy-DEMATEL categorizes the factors as causes and effects. RII scaling is used to scale the factors that cause disputes causing cost overrun in Kerala public works. Thus, this study intends to find the factors affecting disputes, their inter-relationships and effects on Kerala construction sector.

**Keywords** Relative importance Index (RII) · Kerala public works · Fuzzy-DEMATEL · Disputes

## 1 Introduction

Disputes has always had its close acquaintance with construction projects. When the project goals are not met, limitations in the project's implementation will arise. It is necessary to handle the potential for conflicts or disagreements among the stakeholders in the project. Conflict is the result of there being a discrepancy in the values or objectives that must be met, both personally and in relation to others. Conflict can result from numerous sources, which include project scope, human resources, contracts, owners, contractors, consultants, and outside factors. These

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elements have an impact on the effectiveness and productivity of work, which can be disruptive [1]. The occurrence of disputes can be controlled to a certain limit by proper identification of the causes of disputes. This paper aims to find out all possible sources of disputes from literature review, conduct a survey to determine the disputes and its effects on the construction sector, and finally analyse the survey results with fuzzy logics.

## **2 Identification of Factors Causing Disputes in Construction**

### ***2.1 Identification and Classification of Cost Overrun Factors***

There are plenty of factors that cause disputes in construction industry. Francis et al. [2] stated that disputes are costly both in terms of time and money and are often accompanied by the destruction of individual and good working relationships. Sinha and Wayal [3] pointed out that changes to scope occur not only due to the client but due to the stakeholder needs, the physical location, and the prevailing economic environment. Mante et al. [4] suggested that poor communication is one of the salient features of traditionally procured projects, thereby increasing the possibility of disputes. Cakmak and Cakmak, [5] in their work discussed disputes due to design errors. Osman et al. [6], stated that substantial amounts of money and time are spent annually in pursuing differing site conditions (DSC) claims. Naji et al. [7] in their research specified the top 10 sources of disputes as, poorly addressing the impact or effect of changes related to time and cost, EOT, escalation in price, payment failure in reference to contract conditions, suspension of work, defective work, tender evaluation, risk imposed by the contractor or owner, quality of work on-site. Francis et al. [2] and Tabish and Jha [8] stressed the importance of identifying these sources of disputes so that they can be managed more efficiently and effectively. From literature review, nine categories of factors having 52 sub-factors have been identified. A pilot study was conducted with 5 arbitrators and engineers from Kerala Public Works Department. The factors were reduced to 43 under nine different categories. Table 1 shows the identified factors causing disputes in construction projects.

## **3 Questionnaire Survey**

The target group for the questionnaire survey was construction professionals in public sector projects, here, engineers from different departments of Kerala public works department were selected. A total of 30 responses were collected for the survey. The designation of respondents varied from chief engineers, executive engineers and

**Table 1** Factors causing disputes

Sl. No	Main factors	Sub-factors
1	Owner related	Delay in contractor's bill settlement for completed work
2		Slow decision making
3		Delay in handing over site/right of way
4		Administration issues on client side
5		Unrealistic time targets
6	Contractor related	Improper planning and scheduling
7		Poor quality of work
8		Cash flow difficulties
9		Improper site management
10		Technical inadequacy and insufficient experience of contractor
11		Extra charges due to rework
12	Consultant related	Incorrect estimation of cost and time
13		Delay and improper inspection
14		Lack of professionalism
15		Quality assurance and quality control
16	Design related	Modification/change in design
17		Delay in design approval
18		Lack of clarity in specification and drawings
19	Coordination related	Change in scope of work
20		Extra work
21		Exceptionally low bid
22	Material labour equipment related	Price escalation related issues
23		Material shortage
24		Delay in material procurement
25		Modification in material specifications
26		Labour shortage
27		Dispute and strike
28		Poor qualification of labour
29		Labour charge
30		Equipment deficiency
31		Higher cost of equipment and machines
32		Contract related
33	Lack of clarity, inconsistency and overlapping of contractual provisions	
34	Coordination related	Delay in progress of work

(continued)

**Table 1** (continued)

Sl. No	Main factors	Sub-factors
35		Lack of proper coordination between contractor and labour
36		Gaps in communication between client and contractor
37	External factors	Changes in rules and regulations of state and central government
38		Force majeure-act of God
39		Adverse weather conditions
40		Differing site conditions
41		Accidents and casualties
42		Insurance charges
43		Fraudulent and kickbacks

**Table 2** Experience of respondents in construction field

Total experience	Number	Percentage (%)
Less than 2 years	2	6.67
2–5 years	5	16.67
6–10 years	2	6.67
11–15 years	4	13.33
Above 15 years	17	56.67

assistant engineers of different Kerala public works department. From the respondents, 56.67% had more than fifteen years of experience. The demographics of the survey is given in Table 2. The responses of the survey were used to perform DEMATEL Analysis as well as, to rank the factors with RII scale.

### 3.1 Fuzzy DEMATEL Analysis

The Decision-Making Trial and Evaluation Laboratory (DEMATEL) method is used to visualize a structure of complicated casual relationships through matrices or digraphs. Kumaraswamy [9] stated that the varied opinions of project participants regarding the reasons for the issues prevailing in a project is one of the major challenges in tracing the cause-effect links between given categories of claims, specific proximate causes, and root causes.

Fuzzy technique methodologies provide a viable tool for modeling subjective information, and handling uncertainty where comprehensive data sets are not available for modeling [7]. Thus, Fuzzy DEMATEL can be applied to problems that

involve group decision making. The procedure adopted for Fuzzy DEMATEL analysis to determine the cause-and-effect relationship between the main category of factors is as given below [10]:

- Step 1: The problem elements are formed in this step, along with the extent of their interrelationships. Thus 43 factors were collected from literature survey for questionnaire preparation.
- Step 2: The importance of the measurement scales is specified as 0–4, before the preparation of the questionnaire survey. The fuzzy scale adopted in the study is given in Table 3.
- Step 3: The responses in a direct relation matrix are defuzzified, using Eq. (1), which is called the central area method.

$$\text{Center of area} = \frac{a + b + c}{3} \tag{1}$$

where a, b, c are the corresponding TFNs

- Step 4: Average matrix(X) is calculated where each element is the average of corresponding elements from all the responses with its diagonal elements zero. Refer Eq. (2)

$$X = \begin{bmatrix} 0 & \dots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{1n} & \dots & 0 \end{bmatrix} \tag{2}$$

- Step 5: A normalized direct relation matrix (N) is built from direct relation matrix using Eqs. (3) and (4)

$$\lambda = \frac{1}{\max_{1 < i < n} \sum_{i=1}^n x_{ij}} \quad (i, j = 1, 2, \dots, n) \tag{3}$$

$$N = \lambda X \tag{4}$$

- Step 6: The Total relation matrix (T) is calculated based on Eq. (5)

**Table 3** Fuzzy linguistic scale [11]

Linguistic phrases	Influence score	Triangular fuzzy numbers
No influence	0	(0, 0, 0.25)
Very low influence	1	(0, 0.25, 0.50)
Low influence	2	(0.25, 0.50, 0.75)
High influence	3	(0.50, 0.75, 1.00)
Very high influence	4	(0.75, 1.00, 1.00)

$$T = \lim_{k \rightarrow \infty} (N + N^2 + \dots + N^k) = N(1 - N)^{-1} \tag{5}$$

Step 7: From the total relation matrix the sum of all rows and columns are calculated.  $D_i$  shows the sum of the  $i$ th row and  $R_j$  shows the sum of the  $j$ th column  $D_i$  shows the sum of the  $i$ th row and  $R_j$  shows the sum of the  $j$ th column, which in turn denotes the direct and indirect influences between factors Eqs. (6) and (7).

$$D_i = \sum_{j=1}^n t_{ij} (j = 1, 2, \dots, n) \tag{6}$$

$$R_j = \sum_{i=1}^n t_{ij} (j = 1, 2, \dots, n) \tag{7}$$

Step 8: This step involves initial stages of making of the casual diagram or cause—effect digraph.  $D + R$  and  $D-R$  are calculated. Maximum  $D + R$ , prominence value shows that the corresponding factor has more relationships with other factors. They have more influence over other factors. Positive  $D-R$ , relation value however shows that they are cause groups or despatchers, and the negative valued factors are effect groups or receivers.

Step 9: The cause-effect diagram is drawn.

### 3.2 Relative Importance Index

As stated by Gebrehiweta and Luo [12], using a five-point Likert scale, the Relative Importance Index (RII) is used to assess the relative importance of the various causes of disputes due to cost overrun. The more significant the cause, the higher the value of the relative important index (RII), and vice versa. Equation (8) is used for calculation of RII.

$$RII = \frac{\sum W_i F_i}{A * N} \tag{8}$$

where

$i$ —response category index,  $W_i$ —is the weight given by respondents,  $F_i$ —is the frequency of respondent for each weight,  $A$ —is the highest weight and  $N$ —is the total number of respondents. The relative important index (RII) ranges from 0 to 1 (0 not inclusive).

## 4 Results and Analysis

### 4.1 Fuzzy DEMATEL Analysis

- Step 1: The factors were identified and all the responses were collected from respondents.
- Step 2: All the collected responses are cross checked for any mistakes or missing data.
- Step 3: Using Eq. (1) the responses were defuzzified. A sample is shown in Table 4. In Table 4, Owner Related is V1, Contractor Related-V2, Consultant Related-V3, Design Related-V4, Project Related-V5, Material, Labour and Equipment Related-V6, Contract Related-V7, Coordination Related-V8 and External Factors is V9.
- Step 4: Average matrix(X) is calculated with all its diagonal elements zero as shown in Table 5.

**Table 4** Defuzzified sample response

Main factors	V1	V2	V3	V4	V5	V6	V7	V8	V9
V1	0.083	0.250	0.750	0.500	0.250	0.250	0.500	0.500	0.500
V2	0.750	0.083	0.750	0.500	0.750	0.250	0.250	0.250	0.250
V3	0.250	0.500	0.083	0.500	0.750	0.250	0.083	0.083	0.083
V4	0.917	0.750	0.250	0.083	0.250	0.250	0.500	0.250	0.083
V5	0.250	0.500	0.500	0.500	0.083	0.250	0.250	0.250	0.083
V6	0.083	0.917	0.500	0.250	0.250	0.083	0.250	0.250	0.250
V7	0.250	0.500	0.500	0.917	0.500	0.250	0.083	0.500	0.250
V8	0.750	0.500	0.500	0.250	0.750	0.250	0.083	0.083	0.500
V9	0.750	0.500	0.083	0.917	0.250	0.250	0.500	0.500	0.083

**Table 5** Average matrix (X)

Main factors	V1	V2	V3	V4	V5	V6	V7	V8	V9
V1	0	0.769	0.572	0.640	0.666	0.481	0.651	0.666	0.473
V2	0.666	0	0.553	0.598	0.659	0.837	0.719	0.776	0.602
V3	0.522	0.602	0	0.522	0.564	0.511	0.435	0.534	0.378
V4	0.556	0.590	0.590	0	0.602	0.401	0.500	0.488	0.443
V5	0.530	0.666	0.560	0.583	0	0.606	0.500	0.621	0.484
V6	0.553	0.803	0.340	0.412	0.628	0	0.568	0.590	0.564
V7	0.609	0.708	0.386	0.416	0.606	0.572	0	0.439	0.488
V8	0.575	0.690	0.534	0.553	0.553	0.625	0.530	0	0.522
V9	0.446	0.484	0.348	0.424	0.473	0.587	0.397	0.393	0

- Step 5: Normalised direct relation matrix(N) is calculated as per Eqs. (3) and (4). The  $\lambda$  value is 0.184. The N matrix is as shown in Table 6.
- Step 6: Total relation matrix(T) is calculated with Eq. (5) and is shown in Table 7.
- Step 7: The D + R and D-R values are calculated as per Eqs. (6) and (7). The respective prominence (D + R) and relation (D-R) values are given in Table 8.
- Step 8: Maximum prominence value was for contractor related factors, followed by, owner related, project related, material, coordination, contract, design, consultant and external factors. The greater the D + R values, greater will be the factor’s influence on other factors. Whereas the more the D-R value, the more those factors have chance to get influenced by other factors. Positive relation values are called cause group or despatchers. The cause group includes owner, contractor, consultant, design and coordination related factors. While, the effect group with negative D-R value includes, project related factors, material, labour, equipment related, contract and external factors.

**Table 6** Normalised direct relation matrix (N)

Main factors	V1	V2	V3	V4	V5	V6	V7	V8	V9
V1	0	0.142	0.105	0.118	0.123	0.088	0.120	0.123	0.087
V2	0.123	0	0.102	0.110	0.121	0.154	0.132	0.143	0.111
V3	0.096	0.111	0	0.096	0.104	0.094	0.080	0.098	0.069
V4	0.102	0.110	0.109	0	0.111	0.074	0.092	0.090	0.081
V5	0.097	0.123	0.103	0.107	0	0.111	0.092	0.114	0.089
V6	0.102	0.148	0.062	0.076	0.116	0	0.104	0.109	0.104
V7	0.112	0.130	0.071	0.076	0.111	0.105	0	0.081	0.090
V8	0.106	0.128	0.098	0.102	0.102	0.115	0.097	0	0.096
V9	0.082	0.089	0.064	0.078	0.087	0.108	0.073	0.072	0

**Table 7** Total relation matrix (T)

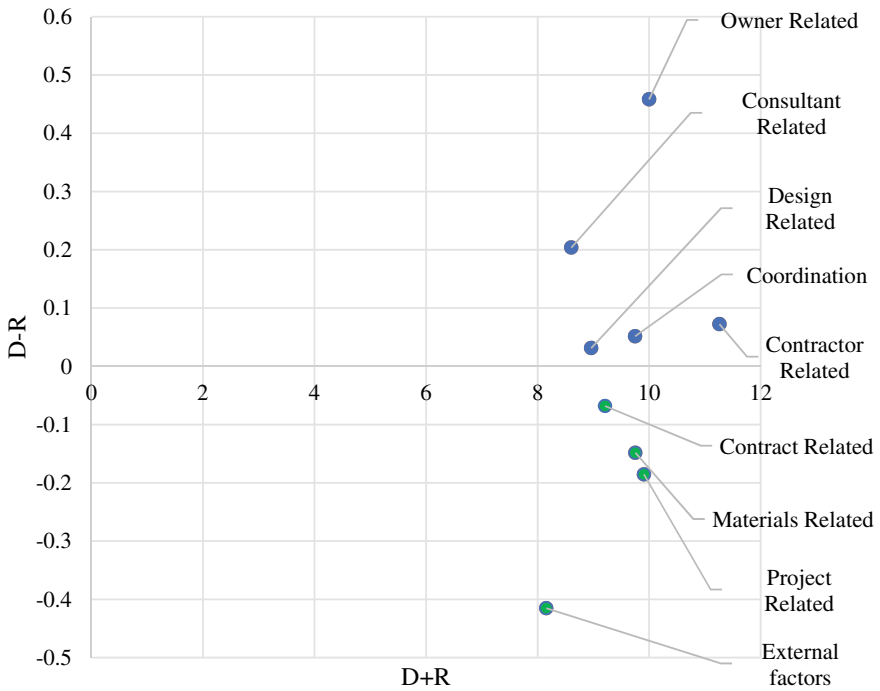
Main factors	V1	V2	V3	V4	V5	V6	V7	V8	V9
V1	0.491	0.700	0.529	0.566	0.629	0.592	0.586	0.610	0.521
V2	0.642	0.625	0.560	0.597	0.671	0.687	0.635	0.667	0.578
V3	0.502	0.585	0.365	0.475	0.532	0.51	0.477	0.511	0.437
V4	0.515	0.594	0.471	0.396	0.547	0.508	0.495	0.512	0.454
V5	0.546	0.645	0.496	0.524	0.483	0.575	0.529	0.567	0.492
V6	0.544	0.65	0.457	0.493	0.581	0.470	0.535	0.558	0.501
V7	0.531	0.620	0.445	0.474	0.555	0.542	0.419	0.513	0.469
V8	0.556	0.654	0.495	0.523	0.579	0.582	0.537	0.468	0.501
V9	0.439	0.508	0.380	0.412	0.465	0.475	0.422	0.438	0.327



**Table 8** Prominence and relation values

Main factors	D	R	Prominence (D + R)	Relation (D - R)
Owner related	5.228517	4.770444	9.998962	0.4580
Contractor related	5.666903	5.594502	11.26141	0.0724
Consultant related	4.404167	4.200418	8.604586	0.2037
Design related	4.495964	4.464698	8.960663	0.0312
Project related	4.860745	5.046109	9.906853	- 0.1853
Material, labour, equipment related	4.802331	4.950724	9.753055	-0.1483
Contract related	4.570609	4.638693	9.209302	- 0.0680
Coordination related	4.900181	4.848728	9.748909	0.0514
External factors	3.870328	4.285431	8.155759	- 0.4151

Step 9: The cause-effect diagram is shown in Fig. 1.



**Fig. 1** Cause-effect diagram

## 4.2 *Relative Importance Index*

This section of study includes analysis of factors that influences the disputes due to cost overrun in Kerala public projects. The frequency of each factor from the collected responses were calculated. A total of 30 responses were collected from the industrial engineers. Equation (8) was used to determine the weightage of each factor. The factors were then arranged in descending order of their weightages. The top 5 factors that came in the list were, material shortage and poor quality of work was weighed 0.808, price escalation related issues with a weight of 0.768, extra charges due to rework with a weight of 0.744, cash flow difficulties from contractor were 0.736, while, unrealistic time targets by owner, improper site management by contractor, delay in handing over of site, and extra works in project have been weighed 0.728. Table 9 shows the weightages of other factors. However, the weights of their corresponding main categories varied as shown in Table 10.

## 4.3 *Validation*

The validation of the study was conducted with another questionnaire survey, where a team of 10 practising arbitrators, responded to the same questionnaire. Their responses were analysed using Relative Importance Index and the corresponding weights for each category were calculated as discussed before. The weights of main factors are shown in Table 11.

## 5 *Conclusion*

Disputes in the construction sector have a long-lasting impact on the progress of work, money and time involved. Thus, identification and prevention of disputes becomes a necessity in construction industry. In the case of public projects, the delay in establishment of a project affects the goodwill and trust of the public in government. Disputes cause a huge loss of money and time for all the stakeholders involved in a project; thus, it is necessary to identify all the probable causes of disputes and eliminate them at the early stages of construction itself.

Forty-three factors causing disputes in construction industry were identified from extensive literature review. A questionnaire survey was conducted with 30 engineering professionals from different departments in Kerala Public Works Department. The responses were analysed with Fuzzy-DEMATEL approach to determine the cause and effects of disputes. The maximum prominence value ( $D + R$ ) was calculated for contractor, followed by, owner, project, material, coordination, contract, design, consultant and external factors. The contractor related factors had more prominence, i.e., they are more connected with other factors. Thus, controlling its

**Table 9** Weightages of sub-factors from RII scaling

Sl. No	Sub-factors	Weightages
1	Material shortage	0.808
2	Price escalation related issues	0.768
3	Extra charges due to rework	0.744
4	Cash flow difficulties	0.736
5	Unrealistic time targets	0.728
6	Improper site management	0.728
7	Extra work	0.728
8	Improper planning and scheduling	0.720
9	Technical inadequacy and insufficient experience of contractor	0.720
10	Delay in design approval	0.720
11	Delay in material procurement	0.712
12	Delay in progress of work	0.712
13	Delay in handing over site/right of way	0.704
14	Slow decision making	0.696
15	Modification/change in design	0.696
16	Change in scope of work	0.696
17	Incorrect estimation of cost and time	0.672
18	Labour shortage	0.648
19	Labour charge	0.648
20	Gaps in communication between client and contractor	0.648
21	Delay in contractor's bill settlement for completed work	0.632
22	Adverse weather conditions	0.624
23	Lack of professionalism	0.616
24	Poor quality of work	0.608
25	Equipment deficiency	0.608
26	Lack of clarity in specification and drawings	0.600
27	Modification in material specifications	0.600
28	Differing site conditions	0.600
29	Administration issues on client side	0.592
30	Dispute and strike	0.592
31	Lack of proper coordination between contractor and labour	0.592
32	Exceptionally low bid	0.584
33	Poor qualification of labour	0.576
34	Delay and improper inspection	0.552
35	Higher cost of equipment and machines	0.552
36	Lack of clarity in tender and agreement clauses and drawings	0.544
37	Force majeure-act of God	0.528

(continued)

**Table 9** (continued)

Sl. No	Sub-factors	Weightages
38	Lack of clarity, inconsistency and overlapping of contractual provisions	0.512
39	Changes in rules and regulations of state and central government	0.512
40	Quality assurance and quality control	0.504
41	Accidents and casualties	0.464
42	Fraudulent and kickbacks	0.432
43	Insurance charges	0.384

**Table 10** Weights of the main factors from the study

Main factors	Weights
Owner	0.653
Contractor	0.66
Consultant	0.621
Design	0.653
Project	0.651
Material	0.652
Contract	0.542
Coordination	0.649
External	0.534

**Table 11** Weights of the main factors from validation

Main factors	Weights
Owner	0.632
Contractor	0.792
Consultant	0.52
Design	0.64
Project	0.584
Material	0.712
Contract	0.52
Coordination	0.616
External	0.48

occurrence can control the chances of disputes to a greater extent. The cause group included owner, contractor, consultant, design and coordination related factors with owner related factors having more influence over other categories. The effect group had project related factors, material, labour, equipment related, contract and external factors. Therefore, external factors have more chances of getting influenced by other factors.

The top-rated factors in RII ranking were, material shortage, price escalation related issues, extra charges due to rework, cash flow difficulties from contractor, unrealistic time targets by owner, improper site management by contractor, and extra works in project. From both the study as well as the validation results, the top-rated main factors were contractor related, owner related, design related and material, labour and equipment related factors. Thus, prevention of occurrence of these factors and their associated sub-factors can control the occurrence of cost overrun in public projects and their related disputes efficiently.

Mitigation measures, to prevent the disputes and litigation due to the top-rated factors like, owner related, contractor related and material, labour equipment related and design related factors in public projects can be as follows:

- i. Tender documents or agreements shall clearly elaborate the responsibilities and obligations of both the parties to the agreement.
- ii. Tender documents or agreements shall specify the time of starting of work and time of completion of work (TOC), which may reduce chances for unrealistic time targets and delay in progress of work.
- iii. The obligations of owner such as supply of power to the site, getting sanction for project from statutory authorities, timely handing over of the site, and ensuring the law-and-order at the site should be fulfilled.
- iv. Bidder or contractor shall study the site conditions such as access to site facility for transport and storage of materials, availability of water and power, etc. before tendering for the work and make provisions for them in their offer.
- v. Better administration and planning by both contractor and client can reduce most of the issues related to material, labour and equipment.
- vi. Pre-contract negotiations, formulation of sound contract agreements, project schedule, documentation and records can help for easier settlement of claims.
- vii. Better contractor selection process, reconfiguration of payment schedules, and escalation payments based on market price can reduce the financial difficulties of contractors to a greater extent.
- viii. Financial difficulties at the client's side can be solved by flexible payment plans and securing the supplies with bank security.
- ix. A few of the measures for design changes can be thorough pre-bid studies, site visits, a clear design philosophy and design management methodology, and deadlines for design delivery.
- x. Usage of advanced tools such as Building Information Modelling (BIM) along with 3D/4D systems can also reduce possible chances of design changes.
- xi. A proper plan for the Resettlement & Rehabilitation (R&R) of project-affected individuals and families may reduce disruptions for the general public, and it also helps to build goodwill of the public.

Hence, this study has identified potential causes of disputes in construction projects. It can help professionals in the early identification of the factors causing disputes thus eliminating every chance of dispute so that projects can be implemented easily, without time or cost overrun.

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