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Critical Uncertainty Factors Impacting Building Construction Projects in India

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Abstract Known Uncertainty (KnU) factors are known to the project stakeholder as knowledge, but their occurrence and cost impact are uncertain in a given construction project. The determination of these factors is subjective at the planning stage. This can be achieved by analysing several projects in a given typology and characterising their occurrence. This paper presents the most critical and important (KnU) factors through extensive literature study, expert judgment, and secondary data. The (KnU) factors were ranked based on literature appearance in selected journals, and the top 30 (KnU) factors were selected for expert judgment to find the top 10 (KnU) factors in the Indian context. Further, secondary data was collected from published records of the Comptroller of Audit General (CAG) of India to find the (KnU) factors in building construction projects that faced cost overruns. The top (KnU) factors from literature, expert judgement and secondary data have been compared and catogorised. Based on the analysis, the (KnU) factors are categorised as the most critical and important. The most critical (KnU) factors are changes initiated by the stakeholder, material price fluctuation, and slow decision making. Based on secondary data, the recommendations for the top 5 (KnU) factors are developed.

Keywords Cost Overrun, Cost Performance, Uncertainty, Relative Importance Index

1. Introduction

The Construction Industry is plagued with time and cost overruns [1, 2], and our country is not an exception. Construction projects possess uncertainty throughout the project lifecycle because the future course of actions contains uncertainty. As the project progresses, the uncertainties are recognised [3]. Cleden [4] says that uncertainty is the source of all risk, and risk management largely focuses on quantifiable threats (and the actions needed to avoid or cope with their consequences), whereas managing uncertainty requires broader and more subtle approaches. The term uncertainty states a lack of knowledge about present and future information and statuses. Chapman and Ward [5] concur that uncertainty is the source of risk. Cleden categorises uncertainty as inherent uncertainty and latent uncertainty. Before attempting to analyse the risks, the uncertainty is called inherent uncertainty. Latent uncertainty remains once all the risks have been identified. In Cleden's [4] four-quadrant model, the known knowns in the first quadrant are not totally immune from uncertainty.

A typical classification of risks is based on the level of knowledge about a risk event's occurrence (either known or unknown) and its impact (either known or unknown). This leads to four possibilities [4]:

- Known–knowns (knowledge),
- Unknown–knowns (impact is unknown, but existence is known, i.e., untapped knowledge),
- Known–unknowns (risks), and
- Unknown–unknowns (unfathomable uncertainty).

The unfathomable uncertainty is not 100% unknown to the project stakeholders because of negligence and lack of effort to find out the uncertainty.

Hence, we conclude that there are known uncertainties in a project, either in their occurrence or in the impact of the known knowledge and unknown knowledge about the events (Known known, unknown known, known unknown and unknown unknown).

Failure to correctly identify and allocate Known Uncertainties in construction projects can result in catastrophic consequences for the parties involved since stakeholders must devote substantial time and resources. As a result, project and organisation managers must make critical economic and contractual agreements to allocate and mitigate uncertainty associated with their operations. The uncertainty factor ultimately leads to the appearance of a risk in a project; to avoid losses due to this, estimators assign contingency costs. The Project Management Institute (PMI) defines contingency in the context of aggressive risk mitigation measures as follows: "The most popular active acceptance technique is to create a contingency reserve, which includes time, money, or resources to deal with the threat if it happens" [6, p. 443].

2. Literature Review

Chapman & Ward categorised uncertainties based on the source of uncertainty, i.e., variability associated with estimates, uncertainty about the basis of estimates, design and logistics, objectives and priorities, and fundamental relationships between project parties. Each category has subcategories, and this categorisation is very project-specific and varies by project. Every activity possesses some degree of uncertainty due to the future being uncertain. For example, project teams know scope changes may be there, but the extent and nature are not known at the planning stage. Moreover, the requirement of the project and technology change, the project value and other circumstances are known to the project teams to a certain extent [5]. These are called known uncertainty in construction projects, ultimately impacting project costs.

Rauzana [7] found 27 uncertainty variables that influence construction cost estimates based on a literature review. Rauzana categorised uncertainty as things that cannot be expected with certainty (that is, unforeseeable), which cannot be clearly stated (intangible), and cannot be predicted (unforeseen), in preparing cost estimates on construction projects. This study is about cost estimation only.

The cost of a project is determined by the type and complexity involved. In general, contractors raise their bid prices in response to known uncertainties. This cost rise may be linked to the known uncertainties in every aspect of uncertainty, such as a lack of engineering data, construction expertise, and operating history record [8].

Flyvbjerg [9] says that the root cause of cost overrun is human bias, psychological and political. This can be seen in many forms in projects. "One's biggest risk is oneself" as per behavioural science, and this is a form of known uncertainty and unknown uncertainty.

Hameed Memon et al. [10] found 15 factors affecting construction project costs in Malaysia. Through fieldwork, Muhammad [11] found 38 factors that cause poor cost management in Nigeria.

Chigara et al. [12] found the factors affecting contractors cost management in Zimbabwe through semi-structured questionnaires and interviews. They are grouped as *exogenous factors*: (labor, materials and plant), funding challenges, and variations, while *endogenous factors include*: organisational, deficient cost control systems and incorrect estimates.

Chaphalkar & Patil [13] found the reason for claims due to the "Variations and Deviations" contract clause in different contracts by studying arbitration awards. The claim reasons are: Change in design during execution, Change in drawing during execution, Change in specifications during execution, Change in quantity of items during execution, Change necessitated due to change in scope of work, Unforeseen circumstances, Additional difficulties in executing the work, Unexpected items at the time of tendering, Rework due to noncompliance with the original work, and Poor artistry of the contractor. These reasons are uncertainties in the project and cause disagreements. Uncertainties in construction contracts: To the project Client: Uncertainty in Land Acquisition, Insufficient resources (land, finance, human power), delay in the project completion (Natural or manmade can cost heavily on client), Increased cost of the project, Deficiencies in infrastructure or services, Design and construction defects, Political risk, and Market risk. Iyer et al. [14] identified dispute prone contract clauses through a questionnaire survey. And found 17 clauses which are prone to claims and disputes. Moza & Paul [15, 16] through analysis of arbitration disputes found root causes of disputes in CPWD (Cantal Public Works Department, Government of India) general conditions of contracts (GCC) and suggested modifications.

These studies are about a specific country and related to estimation, organisational, human bias and claims, which are known uncertainties in the project impacting construction project cost.

3. Need for the Study

Previous research focused on finding factors contributing to cost overruns in construction projects of a generic nature [17, 18, 19, 20, 21, 22, 23]. Some [24, 25] focused on finding the cost impacting factors in public infrastructure projects, but in the building sector, there are a few [26, 27]. To bridge this gap, this research has been taken. The need of the study is to establish the known uncertainty factors in building construction projects. So that, the findings may help in strengthening the current practices in Indian construction.

The objective of this study is to find out the known uncertainty factors impacting building construction project cost in Indian context.

4. Research Methodology

The known uncertainty factors are identified through literature using the keywords 'Cost Overrun', 'Cost Performance', 'Uncertainty', 'Risk', 'Claims', 'Cost Uncertainty' and 'Cost Escalations'. The literature is from nationally and internationally published journals on Google scholar. A total of 24 published papers are chosen. Based on literature frequency, the top 30 factors are selected. A questionnaire is prepared to determine the known uncertainty factors impacting construction project costs in the Indian context. The respondents are asked to specify their agreement on Likert scale (5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, 1 = strongly disagree). The questionnaire was sent to 9 industry experts having more than 20 years of experience. The responses are analysed by using the Relative Importance Index. Secondary data is taken from published Comptroller of Audit General (CAG) of India reports, from 2011 to 2020, of a department which earlier found considerable cost overruns from 2000 to 2009 in Ramachandran's thesis [28]. From CAG reports, the reasons are listed based on the repeated appearance of the KnU factors. The top five factors are chosen, solutions are developed and finally conclusions are drawn.

5. Known Uncertainty Factors in Construction Projects Based on Literature

The (KnU) factors that appeared repeatedly in literature are shown in Table 1.

Table 1. Known uncertainty factors from literature frequency (Source: Authors)

	Cost Impacting Factor	Authors	frequency
1	Improper Management by Project Management Team	[7], [11], [17], [22], [23], [31], [32] [34] [35] [36] [37] [38] [40] [41] [42] [43] [44] [47] [48]	20
2	Shortage of Labour	[10] [20] [22] [30] [31] [32] [34] [35] [36] [39] [40] [41] [42] [43] [44] [45] [46] [47] [48]	19
3	Frequent Design Changes	[7] [10] [11], [20], [23], [31] [32] [34] [35] [36] [39] [40] [41] [44] [46] [48]	16
4	Ambiguity in Contract Conditions	[7], [17], [20] [22] [23] [29], [36], [40] [41] [42] [43] [44] [47] [48]	14
5	Inclement Weather Conditions	[11] [20] [22] [23] [31] [33] [34], [36] [39] [40] [41] [43] [45] [48]	14
6	Scope Change and Additional Work	[10], [20], [23], [31] [32], [34] [35] [36] [39] [40] [41] [44] [46] [48]	14
7	Wrong method of estimation	[11], [20], [30] [31] [32] [33] [34] [35] [36] [37] [41] [43] [48] [46]	14
8	Cash Flow Problems	[7] [10] [11] [20] [22] [30] [32] [34] [35] [36], [40], [43] [47]	13
9	Fluctuation of Materials Prices	[10] [11] [17] [20] [22] [32] [33], [35], [40], [43] [46] [47]	12
10	Slow Decision Making	[10] [11] [17] [20] [22] [32], [35], [39] [40] [43] [44], [48]	12
11	Unforeseen Ground/Site Conditions	[7] [10] [11], [20], [31], [32] [33], [35], [40] [41], [48]	11
12	Inflation	[7] [17] [20] [22] [33] [34], [36], [40], [43] [46] [47]	11
13	Conflicts between Clients and contractors	[11] [20], [30], [31], [34], [36], [40] [43], [44] [46]	11
14	Practice of assigning contract to lowest bidder (Wrong Bidding Method)	[10], [20], [32], [35], [37] [39] [40], [42], [43] [44], [48]	11
15	Discrepancy in Planning/ Design/Scope	[7] [17], [20], [31], [32] [33] [35] [41] [43] [44]	10
16	Lack of Mechanism for coordination and control	[20], [29], [36] [37] [38], [41], [43] [47] [48]	9
17	Improper Contractual Procedure	[11], [20], [22], [34] [36] [37], [40], [43] [44]	9
18	Poor Contract Management	[20], [22] [31] [32] [37] [40] [42] [43] [44]	9
19	Contractor's Poor Site Management and Supervision	[10], [20] [22] [31] [32] [36] [37] [40] [43]	9
20	Improper Supplier or Subcontractor Selection	[20], [31], [38] [39] [40], [42] [43] [44] [48]	9
21	Delay in Approvals	[17] [20] [22] [32], [39] [40] [43] [44], [48]	9
22	Delay in Design / Drawings	[17] [20] [22] [31], [39] [40] [43] [44], [48]	9
23	Low productivity of labour	[22], [20], [40] [41] [42] [44] [45] [46] [47]	9
24	Improper selection of consultants	[20], [32], [39] [40], [42], [43], [44] [48]	8
25	Misrepresentation and Negligence by stakeholders	[7] [10] [11] [30] [31] [32] [33]	7
26	Rework	[20] [31] [32] [40] [43] [44] [48]	7
27	Poor execution by subcontractor	[20], [22] [31] [36] [40] [44]	6
28	Contractor's Experience	[10] [32] [33] [34] [35] [36]	6
29	Delayed Payment to contractor	[20], [31] [32], [35] [36] [47]	6
30	Social conditions/ cultural	[7] [11] [31] [33] [34] [35]	6

A questionnaire is prepared to find out the known uncertainty factors impacting construction project cost in Indian context. The respondents are asked to specify their agreement on Likert scale (5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, 1 = strongly disagree). The questionnaire was sent to 9 industry experts having more than 20 years of experience. The relative importance index (RII) method is applied. The authors observed that RII analysis allows identifying the most important uncertainty and is an appropriate tool to rank on the chosen scale [49]. The RII is calculated for each uncertainty by using the equation1

$$RII = \Sigma W/AxN \ (0 \leq RII \geq 1) \quad (1)$$

Where RII = relative importance index; W = weighting given to each factor by respondents (ranging from 1 to 5); A=highest weight (i.e., 5 in this case) and N = total number of respondents. The RII value has a range of 0 to 1 (0 not inclusive). The higher the RII, the more important the indicator. The RII's Known Uncertainty factor and the results are shown in Table 2.

Table 2. RII ranking of Known Uncertainty factor impacting construction cost (Source: Authors)

Sl.No	Known Uncertainty factor impacting construction project cost	RII	Rank	Related to
1	Cash Flow Problems	0.725	1	Client
2	Contractors Poor Site Management and Supervision	0.7	2	Contractor
3	Delayed Payment to contractor	0.7	2	Client
4	Poor execution by subcontractor	0.7	2	Contractor
5	Delay in Approvals	0.675	5	Other
6	Practice of assigning contract to lowest bidder (Wrong Bidding Method)	0.65	6	Client
7	Shortage of Labor	0.65	6	Other
8	Fluctuation of Materials Prices	0.65	6	Other
9	Slow Decision Making	0.625	9	Client
10	Frequent Design Changes	0.6	10	Client
11	Scope Change and Additional Work	0.6	10	Client
12	Conflicts between Clients and contractors	0.6	10	Client/Contractor
13	Delay in Design / Drawings	0.6	10	Client
14	Low productivity of labour	0.6	10	Contractor
15	Rework	0.6	10	Contractor
16	Contractor’s Experience	0.575	16	Contractor
17	Discrepancy in Planning	0.55	17	Client
18	Improper selection of consultants	0.55	17	Client
19	Social conditions (Strikes)	0.55	17	Other
20	Improper Management by Project Management Team	0.525	20	Client/Contractor
21	Wrong method of estimation	0.525	20	Client
22	Inclement Weather Conditions	0.525	20	Other
23	Unforeseen Ground/Site Conditions	0.525	20	Other
24	Inflation	0.525	20	Other
25	Improper Supplier or Subcontractor Selection	0.5	25	Client
26	Misrepresentation and Negligence by stakeholders	0.5	25	Client/Contractor
27	Lack of Mechanism for coordination and control	0.5	25	Client/Contractor
28	Ambiguity in Contract Conditions	0.475	28	Client
29	Poor Contract Management	0.475	28	Client/Contractor
30	Improper Contractual Procedure	0.45	30	Client

Table 2 shows the RII and overall ranking of the known uncertainties. The ranking classifies the proportion of respondents who placed the highest level of agreement (strongly agree or agree) on each factor. This means that ranking 1 indicates that the stakeholders consider the particular factor.

It is found that the cash flow problem has the highest importance level. The contractor's poor site management and supervision, poor execution by subcontractors, and delayed payment to the contractor have got the next highest level of agreement.

6. Secondary Data Analysis

For this purpose, the records of the Comptroller of Audit General (CAG) of India are chosen from the year 2010 to 2019. Out of 71 records, 40 Infrastructure Projects related to Building construction were found. The issues related to the Clients are: Issues within the Clients Organization, Delay in sanction, Work started without approvals, Related to facilities, Violation of decision, Issue of Funds, Inflated estimate, No levy imposed on the contractor, Cost Escalation, Scope change and Delay in approval of revised estimates. The contractor related issues are: Poor Quality, Slow Progress, Revised estimate not prepared, schedules of Rates revised, and Operational Issues. Other Issues: Issues of Consultants, Weather Conditions, Non-availability of material.

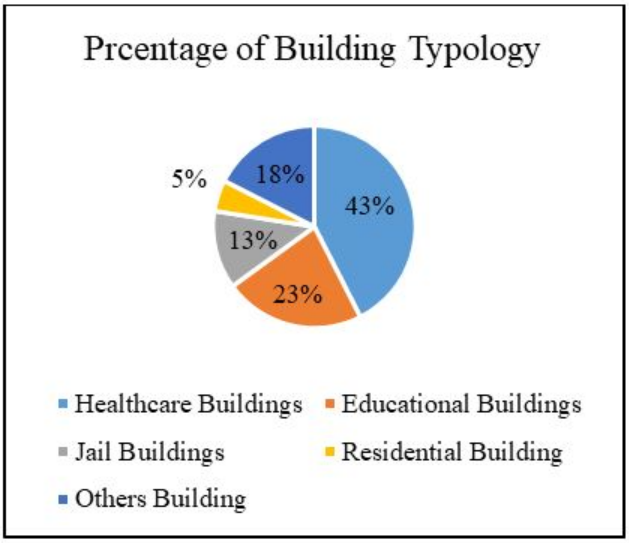

Figure 1. Typology of buildings (source: Authors)

Figure 1 shows the percentage of various typologies of buildings from the cases. Based on the CAG records, Healthcare (43%), Educational (23%), Jails (13%), Residential (5%), and other buildings (18%) are found. The repeatedly occurring known uncertainties in those cases based on the building type are presented in table 4 to table 6.

Table 3 shows the frequency of the known uncertainty factors occurrence in the Secondary Data. Moreover, they are subcategorised as client-related issues, contractor related issues and others. Based on the reported occurrence, ranks are provided.

Table 3. The ranking of the (KnU) factor based on repeated appearance in the Secondary Data (Source: Authors)

Cost Impacting (KnU) Factors	Repeated Appearance	Rank
Issues related to the Clients		
Scope change (Frequent Design Changes)	8	1
Delay in approval of revised estimates	8	1
Issue within Clients Organization	5	4
Delay in Approvals	5	4
Related to facilities	5	4
Violation of decision	4	7
Cost Escalation	3	9
Work started without approvals	3	9
No levy imposed on contractor	2	11
Issue of Funds	2	11
Inflated estimate	1	14
The contractor related issues are		
Poor Quality of work	4	7
Slow Progress	2	11
Revised estimate not prepared	1	14
Operational issues	1	14
Other Issues		
Schedule of Rates Revised (Fluctuation of Materials Prices)	6	3
Issues of Consultants	1	14
Weather Conditions	1	14
Non availability of material	1	14

The typology of building construction and the known uncertainty factors are presented in table 4 to table 6.

Table 4. The client-related (KnU) factors repeated appearance in the Secondary Data based on Building typology (Source: Authors)

Issues related to the Clients (Repeated Appearance)					
Cost Impacting (KnU) Factors	Hospital Building	Educational Buildings	Jail Buildings	Residential Buildings	Other Type of Buildings
Delay in approval of revised estimates	4	2	2		
Scope change (Frequent Design Changes)	3		1	1	3
Delay in Approvals	3			1	1
Issue within Clients Organization	2	3			
Related to facilities	2	1	2		
Work started without approvals	1	1			1
No levy imposed on contractor	1		1		
Issue of Funds	1		1		
Violation of decision		1			3
Cost Escalation		1	1	1	
Inflated estimate			1		

Table 5. The contractor related (KnU) factors repeated appearance in the Secondary Data based on Building typology (Source: Authors)

The contractor related issues			
	Hospital Building	Educational Buildings	Jail Buildings
Slow Progress	1		1
Operational issues	1		
Poor quality of work		4	
Revised estimate not prepared		1	

Table 6. The Other related (KnU) factors repeated appearance in the Secondary Data based on Building typology (Source: Authors)

Other Issues					
	Hospital Building	Educational Buildings	Jail Buildings	Residential Buildings	Other Type of Buildings
Schedule of Rates Revised (Fluctuation of Materials Prices)	2	1	1	1	1
Issues of Consultants	1				
Non availability of material				1	
Weather Conditions					1

7. Discussions

Based on the literature, the known uncertainty factors are categorised as client-related, contractor-related, and other issues.

Client related: Cash Flow Problems, Delay in Approvals, Practice of assigning the contract to lowest bidder (Wrong Bidding Method), Frequent Design Changes, Scope Change and Additional Work, Discrepancy in Planning, Improper selection of consultants, Improper Management by Project Management Team, Wrong method of estimation, Improper Supplier or Subcontractor Selection, Ambiguity in Contract Conditions, and Improper Contractual Procedure.

The client related factors are considered very important in achieving the cost objective. From RII (0.725), the Cash flow problem is ranked first. The project sponsors have to prepare in terms of finance so that this issue can be sorted. Based on case studies, the scope changes and delays in approval of revised estimates are observed repeatedly. This indicates that robust planning is needed to achieve the cost objective.

Contractor related: based on literature, Contractors Poor Site Management and Supervision, Delayed Payment to the contractor, Shortage of Labor, and Contractor's Experience.

The RII (0.7) Contractors Poor Site Management and Supervision and Delayed Payment to the contractor are the first and second rank in the contractor related factors and second rank in the overall ranking. This indicates that the contractor's way of work and supervision needs improvements. Moreover, the client's cash flow problems indirectly affect the contractor's performance. The secondary data analysis shows that poor quality is the highest occurring factor in the contractor related factors. In this factor, there is an agreement in the RII and case study.

Other: Poor execution by a subcontractor, Fluctuation of Materials Prices, Low labour productivity, Rework, Social conditions (Strikes), Inclement Weather Conditions, Unforeseen Ground/Site Conditions and Inflation. Based on RII (0.7), it ranked first in this category and ranked second in the global rank. This factor is not observed in the case studies. Sub-contracting is not permitted in the government project in India, but through the client's approval, the work may be given through specialist vendors. In general, the control of this type of subcontractor is not in the main contract. There are many subcontractors depending on the project size and complexity. The overall effect of such a subcontractor on the cost object has to be studied. The top 10 ranking Known Uncertainty factors based on Literature frequency, RII and Secondary Data are tabulated in Table 7.

Table 7. Known Uncertainty factors based on Literature frequency, Expert opinion (RII) and Secondary Data (Source: Authors)

Literature	Expert opinion (RII)	From Secondary Data	Rank
Improper Management by Project Management Team	Cash Flow Problems	Scope change (Frequent Design Changes)	1
Shortage of Labour	Contractors Poor Site Management and Supervision	Delay in approval of revised estimates (Slow Decision Making)	2
Frequent Design Changes	Delayed Payment to contractor	Schedule of Rates Revised (Fluctuation of Materials Prices)	3
Ambiguity in Contract Conditions	Poor execution by subcontractor	Issue within Clients Organization	4
Inclement Weather Conditions	Delay in Approvals	Delay in Approvals	5
Scope Change and Additional Work	Practice of assigning the contract to lowest bidder (Wrong Bidding Method)	Related to facilities	6
Wrong method of estimation	Shortage of Labor	Violation of decision	7
Cash Flow Problems	Fluctuation of Materials Prices	Poor quality of work	8
Fluctuation of Materials Prices	Slow Decision Making	Cost Escalation	9
Slow Decision Making	Frequent Design Changes	Work started without approvals	10

Though the ranking is given based on 'Literature', Expert Judgment and Secondary cases, the considerations can be as follows:

The Frequent Design Changes, Slow Decision Making, and Fluctuation of Materials Prices are ranked in the top 10 in the three studies. These can be considered as the most critical (KnU) factors in building construction projects and other infrastructure projects. The design change is one of the causes of the scope change so that the design change and scope change can be considered as 'changes' in the project during execution. Furthermore, the change appears twice in the top 10 ranks of literature as design change and scope change.

The critical category of (KnU) factors are shortages of labour, cash flow problems, poor quality of work, and delay in approvals appearing in any two studies conducted.

The third category is important (KnU) factors because these are found in the top 10 ranks of the studies, but there is no coincidence with the other ways of study findings. The important (KnU) factors are Improper Management by Project Management Team, Ambiguity in Contract Conditions, Inclement Weather Conditions, Wrong method of estimation, Contractors' Poor Site Management and Supervision, Delayed Payment to contractor, Practice of assigning contract to lowest bidder (Wrong Bidding Method), Issue within Clients Organization, Related to facilities, Violation of decision and Work started without approvals.

8. Recommendations

The recommendations for the top 5 (KnU) ranked factors from Secondary Data are:

8.1. Scope Change

- Scope changes are the highest in the cases observed. It indicates that the client's requirement's translation into plans is very poor. The translation of the client's requirements into plans needs improvement. To achieve this, the client's team and the designer's team coordination plays a significant role. It includes the finalisation of the specification before the contract is awarded. Clients should arrange the needed funds to execute the project.

8.2. Delay in Approval of Revised Estimates

This uncertainty persists due to interdepartmental issues within the government and the lack of decision-making in authority. The initial budget approvals of the projects are misrepresented by fewer budgets and launching the project, but the reality is realised during the project execution stage.

- To eliminate this issue, the client's management has to be realistic in determining the project budget at the initial approval stage.

8.3. Schedule of Rates Revised

The projects duration beyond one year the contracts has the exception clause included in the traditional contracts in public projects.

- The solution to this issue is to determine the additional budget to cater to the revised rates according to the market conditions.

8.4. Issue within Client's Organisation

The start of work without prior approval of the concerned authority leads to the work's abandonment. Starting the project without proper approval from the concerned department.

- The execution of Projects should not start prior to approvals. The contracts also include the responsibilities of the client's team.

8.5. Delay in Sanction

The procedures in the client's organisation hinder the project often. Delay in approvals from various departments and contractual procedures is the predominant ones.

- A single point approval process should be developed.

9. Conclusions

This paper identified the Known Uncertainties impacting building project cost based on literature appearance, expert judgment, and secondary data. The top 10 known uncertainty factors are the most critical, critical and important (KnU) factors.

The most critical (KnU) factors are Scope Change or Frequent Design Change, Slow Decision Making and Fluctuation of Materials Prices.

The critical category of (KnU) factors are shortages of labour, cash flow problems, poor quality of work, and delay in approvals.

The important (KnU) factors are Improper Management by Project Management Team, Ambiguity in Contract Conditions, Inclement Weather Conditions, Wrong method of estimation, Contractors Poor Site Management and Supervision, Delayed Payment to contractor, Practice of assigning contract to lowest bidder (Wrong Bidding Method), Issue within Clients Organization, Related to facilities, Violation of decision and Work started without approvals.

The known uncertainty factors from literature, expert judgment and secondary data show that the ranking is not 100% matching but the factors are relevant to certain degree in the case studies, indicating that these factors are specific to the organisation, project type, project location, type of contract used in the project and others. The found known uncertainty factors can be used to identify and develop mitigation measures, and the impact of the interdependencies of these factors can be further explored specific to the projects.

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