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Critical success factors affecting project success in construction projects: A contemporary Indian perspective

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A B S T R A C T

The government of India has increased its focus on investment in infrastructure, allocating US$ 130.57 billion in 2022-23 for the sector. Effective project management is crucial for success. However, despite a huge body of knowledge on project success, project delays persist, with 33% of projects delayed by an average of 47 months as of August 2021. This study aims to identify Critical Success Factors for contemporary construction projects in India, offering guidance for project stakeholders. Forty-five attributes of project success were collated from literature and expert discussions and a questionnaire survey was conducted to solicit the views of experts on the critical impact of these attributes on overall project success. The research posits that these attributes have underlying constructs that cause them. Factor analysis was employed to extract the underlying constructs. Six critical success factors (CSF) were extracted. To comprehend the relative importance of the factors, RII was employed on summated factor scores that were then ranked in order of their importance. ANOVA showed consistent assessments of the CSFs across professional roles and geographies. The findings are expected to aid project professionals in prioritizing key factors for optimal project management and successful outcomes.

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1. Introduction

The progress of a nation's economy is intricately linked to the development of its infrastructure, a pivotal driver for growth across diverse sectors. In the case of India, the insufficiency of its infrastructure remains a significant bottleneck to sustained economic advancement. This inadequacy in crucial areas such as transport, sanitation, and electricity continue to pose a substantial challenge to the country's economic expansion, particularly in sectors reliant on robust infrastructure. Conservative estimates suggest that this infrastructure deficit annually shaves off a substantial 1-2 per cent of India's GDP growth (NCAER, 2011). To address this pressing need, the Indian government has significantly intensified its focus on infrastructure development, as evident from initiatives like the 10th and 11th Five-Year plans. Over the past decade, investments in infrastructure have surged, with the 2022-23 budget earmarking a substantial Rs. 10 lakh crore (US$ 130.57 billion) towards strengthening the infrastructure sector. Despite these substantial investments, the sector grapples with project delays, as indicated by quarterly reports from the Ministry of Statistics and Programme Implementation (MoSPI), which reported that nearly 33% of infrastructure projects were delayed as of August 2021, with an average delay of approximately 47 months. Optimal execution of infrastructure projects plays a crucial role in ensuring the desired success of such investments. Project management, though recognized as a powerful tool in addressing persistent challenges like cost-time overruns, has shown limitations in effectively addressing and controlling construction projects (Gwaya et al., 2014).

To bridge this gap, extensive global research has focused on identifying Critical Success Factors (CSFs) essential for achieving optimal project performance. However, these factors vary based on project specifics like project type, location, and other variables. As a result, there's no universal set of success factors applicable to all projects. Furthermore, research thus portrays perceptions existing in the industry of that period while the construction industry changes and evolves continuously. Due to this, it would not be advisable to assume permanency in such success factors.

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This research aims to contribute to existing knowledge by conducting a thorough examination of Critical Success Factors (CSFs) crucial for successfully executing construction projects in the contemporary construction sector. Through detailed analysis, this study aims to gather a few key factors that significantly influence the successful outcomes of construction projects. The findings will serve as a valuable guide for project managers and stakeholders in the present day construction industry.

2. Literature Review

Research on project success has been going on for decades and essentially delves into different branches ranging from the definition of project success, finding attributes that lead to a successful project, finding underlying factors of success and measuring the performance of a project while defining the different criteria for measuring the success.

Sanvido et al., (1992) defined success for a given project participant as the degree to which project goals and expectations are met, adding that these goals and expectations may include technical, financial, educational, social, and professional aspects. Studies like these not only laid the foundation for defining project success but also paved the way for further research on what could be the criteria for success and what could be the factors that could help in achieving success. While ‘success criteria’ are the standards on which a judgment or decision regarding project success is based (Gibson & Hamilton, 1994), ‘critical success factors’ (CSFs) are the few key areas of activity in which favourable results are necessary for a particular manager to reach his or her goals (Rockart, 1982).

Ashley et al. (1987) grouped 46 factors into five categories of Management, Organization, and communication; Scope and planning; Controls; Environmental, economic, political, social and Technical which were then rated in order of their importance and the top 11 factors affecting the success of a project were identified as Planning effort, Project manager goal commitment, Project team motivation and goal orientation, Scope and work definition, Project manager capability and experience, Safety, Control systems, Design interface management, Risk identification and management, Technical uncertainty and Legal political environment.

Schultz et al. (1987) were among the first researchers who classified the success factors into two groups *Strategic* (The Planning) and *Tactical* (the doing) and presented a framework of ten critical success factors under two groups. These two groups of factors affect project performance at different phases of implementation. The strategic group includes factors such as “project mission”, “top management support” and “project scheduling” whereas the tactical group consists of factors such as “client consultation”, and “personnel selection and training” (Schultz et al., 1987). Belassi and Tukel (1996) in their study furthered this concept of classification and proposed a classification framework for project success factors, emphasizing the grouping of factors based on their relation to the project, project manager, team members, organization, and external environment. This approach enables a more effective evaluation of projects by considering the combined effects of factors within each group.

The identified success factors, however, have been specific to an organization or a project type and may not be generalized to a wider gamut of construction project implementation (Boynton & Zmud, 1984; Shank et al., 1985). The absence of a standard or a generalized base for success factors in a project implementation process has resulted in disagreement on the set of critical factors that are related to the implementation of success strategy (Pinto & Slevin, 1987). This issue was addressed by the authors by developing a framework for the project implementation process and diagnostic instrument for a project manager. The instrument was developed by the researchers by way of field research and was called the Project Implementation Profile (PIP) which identified ten critical factors like Project mission, Top management support, Project schedule/plans, Client consultation, Personnel, Technical tasks, Client acceptance, Monitoring and feedback and Communication for project implementation success.

Though a lot of work has been done in identifying success factors for project success in general, in reality, the factors affect different project objectives differently (Jaselskis & Ashley, 1991). Atkinson, (1999) while reviewing the success criteria in his research concluded that project management must look beyond the iron triangle of project objectives and include other criteria like benefits to the organization, benefits to stakeholders etc. Consequently, it can be argued that success factors within a project would be affecting different project objectives or success criteria differently and therefore for project management to succeed, identification of success factors and their effect on success criteria was important. Chua et al. (1999) identified the 10 most critical success factors for different project objectives of a construction project from sixty-seven success-related factors identified from the literature and were grouped under four project aspects viz project characteristics; contractual arrangements; project participants, and interactive process. Many studies followed similar lines where CSFs were identified for different project objectives for various types of construction projects, set in different geographies. For example, Iyer and Jha (2005, 2006) conducted a study for CSFs for different project performance criteria of Schedule, Cost, Quality and No Dispute in the Indian context and identified Project manager’s Competence, Supportive Owners and Top Management, Monitoring, Feedback and Coordination, Favourable Working Conditions, Commitment of All Project Participants and Owner’s Competence as seven CSFs.

Another aspect of success factors that has been studied by researchers is the applicability of CSFs for different project types. It was hypothesised by the researchers that the CSFs for a construction project would vary from project type to type depending upon various factors like scale, geography etc. and is largely driven by the perception of stakeholders concerned with the project (Toor & Ogunlana, 2009). Parfitt and Sanvido (1993) were among the early researchers who looked at the applicability of CSFs for a particular project type. The researchers while looking at only building projects determined the existence of four CSFs in building projects viz well-organized team, well-defined contract, experience of similar facilities; and timely optimization information from stakeholders.

Distinctions between public and private sector projects have also been investigated, revealing variations in perceived success factors (Divakar & Subramanian, 2009; Tabish & Jha, 2011). For public projects, factors like rule compliance, pre-planning, effective partnering, and external monitoring were deemed crucial.

From the discussion above, it can be observed that considerable work on success factors has been done. The list of success factors identified is too exhaustive and it cannot be generalized for any setting because the factors have been identified for different types of projects, different stages of projects, different sectors of the construction industry, different geographies and using different research methods.

However, it is recognized that research on project success factors needs further effort. Too general or too specific success factors in previous studies present certain difficulties when practically applied. In addition, and more importantly, the research on success factors done earlier includes the perception of respondents in the contemporary setting of a project environment. Progressively, the management of projects has undergone a significant change with the introduction of new technology, tools and practices etc and hence the success factors identified previously may not hold for a project with similar characteristics in today's contemporary setting.

Consequently, any research on project success should first identify pertinent factors specific to the construction industry within a particular geography, and in the current context. With this in mind, this study, being part of ongoing research on the interaction between success and delay factors, aims to ascertain the critical success factors in the present-day Indian construction industry, prioritising them by importance. The research hypothesis posits that, amid the numerous factors or attributes identified in earlier studies, there likely exist secondary constructs that can elucidate the manifestation of these recognized success attributes. Once isolated, these secondary constructs can offer a more concise explanation using fewer variables, constituting what can be termed Critical Success Factors in the present context.

3. Research Method

The present study involves analysing attributes of success in a construction project. However, it is seldom the case that such data is available in documented project records. Additionally, assuming such data were available, it would need a large number of such projects to generalize inferences from the research, which is difficult to get. Therefore, the research method necessitates analysing the perception-based responses from the construction field for obtaining underlying factors from manifest variables called attributes. Consequently, empirical quantitative research design using cross-sectional survey methodology appeared suitable for the current research because a general sample survey provides first-hand primary data that is reliable, accurate, and applicable to the research goals and is considered a good tool for investigating the perceptions based on the experience of the targeted population (McCombes, 2022).

3.1 Data Collection, Analysis & Results

3.1.1 Survey Design

Fifty-four success attributes were initially compiled through a literature review and expert discussions. The discussions ensured the inclusion of attributes not in the literature but could represent the present-day construction ecosystem like the ones related to technological interventions, mechanization etc.

The first section of the questionnaire gathered detailed information about project participants, including personal, and demographic data, and their experience in the construction industry. This aimed for a diverse and representative sample. Respondents then rated the effect of success attributes on overall project success using a 5-point Likert scale. An open-ended question invited suggestions for additional attributes related to project success.

A pilot survey with 20 construction experts led to modifications in the questionnaire, including one additional demographic question and the removal of nine attributes that seemed similar in interpretation. The final questionnaire contained 45 success attributes or variables.

3.1.2 Sampling Design

Reaching a targeted audience of experienced construction-related participants across diverse projects nationwide is not easy through traditional random sampling as it is resource and time-intensive. Consequently, the adoption of snowball sampling for precision and efficiency is considered appropriate (Leighton et al., 2021). This method leverages existing networks, ensuring precise targeting of the intended group (Parker et al., 2019).

An initial list of respondents ("Seeds") from various organizations was compiled, including CPWD, project management consultants, and industry-leading firms like Colliers and CBRE. Vendor lists of organizations were also pursued to get contact details of the contractors. The survey, designed as outlined above, was conducted online using Google Forms with mandatory responses to avoid missing data. Two hundred eight (208) such experts were selected as first-level respondents.

A total of 213 responses were collected in the online survey, with 117 originating from initial-level respondents (208) or seeds. The snowballing technique contributed an additional 96 responses. This total falls comfortably within the recommended sample size range of 100 to 240 for Exploratory Factor Analysis (EFA) as suggested by various researchers (Hogarty et al., 2005; Velicer & Fava, 1998) This also corresponds to the N:P ratio of 5 as recommended by Gorusch, (1983) for Exploratory Factor Analysis.

Initial data analysis was conducted in SPSS version 27 software, including correlational and reliability assessments.

Table 1

Test of internal consistency

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No. of Items
0.963	0.964	45

Cronbach's Alpha, denoted as "α", was used to gauge the internal consistency or reliability of questionnaire items. A threshold of 0.7 indicates acceptable internal consistency (George & Mallery, 2003; Nunnally & Bernstein, 1994). Results reveal acceptable alpha values exceeding 0.9 indicating high internal reliability. The correlation matrix also showed moderate correlations (between 0.3 and 0.5) between variables, with 418 correlations above 0.3.

Given the above considerations, the sampling size of 213 seemed adequate and fit for pursuing further exploratory factor analysis.

3.1.3 Data Screening

Before performing an exploratory factor analysis (EFA), it is essential to thoroughly examine the data for any potential biases that could impact the results (Hair et al., 2019). These biases may arise from factors like limited score variability, data distribution patterns, outliers, and missing data (Tabachnick & Fidell, 2019).

Limited score variability, where values cluster in a narrow range, can skew statistical analyses like correlation and consequently EFA (Lorenzo-Seva & Ferrando, 2020). The study's comprehensive survey approach, including a diverse range of construction professionals in various roles, helps ensure a balanced representation of the construction expert population thereby avoiding a similar response range.

Table 2

Demographic Distribution of Respondents

Role	Nos	Percent	Experience	Nos	Percent	Project Size	Nos	Percent
Client/Owner	58	27.2	< 5 years	30	14.1	< 5 Cr	25	11.7
Contractor	53	24.9	5 - 10 Years	46	21.6	5 - 10 Cr	12	5.6
Consultant	102	47.9	10 -15 Years	54	25.4	10 - 50 Cr	41	19.2
			> 15 Years	83	39.0	50 -100 Cr	51	23.9
						> 100 Cr	84	39.4
Total	**213**	**100**		**213**	**100**		**213**	**100**

This is also verified by the descriptive analysis of the variables which report that the range of responses for all variables is between 3 and 4. On a five-point Likert scale that signifies a wide range of scores.

However, the descriptive analysis also indicates that certain variables have mean < 3 and median scores of 2 or lower, suggesting limited perceived importance of these attributes to project success. These five variables are removed, leaving 40 attributes for analysis.

Table 3

List of variables removed due to low average & median scores

Variables (Success Attributes)	N	Mean	Median
SA38_Favourable geo-political conditions	213	2.70	2.00
SA39_Favourable socio-economic conditions	213	2.54	2.00
SA42_Use of technological interventions in project management	213	2.72	2.00
SA43_Use of advanced mechanization in execution	213	2.83	2.00
SA44_Using UpToDate technology and automation	213	2.73	2.00

Univariate normality test results of Skewness=1.138 and Kurtosis=1.148 fall within acceptable limits 2.0 and 7.0 respectively (Curran et al., 1996; Fabrigar et al., 1999) indicating a normal univariate distribution of the data. Using Mardia, (1970) multivariate normality test, the data reveals significant deviations in both skewness and kurtosis, indicating a lack of multivariate normality (Table 4). The absence of multivariate normality restricts the choice of extraction methods for EFA to more suitable models (Watkins, 2021).

Table 4
Multivariate normality test results

Success Attributes	b	z	p-value
Skewness	524.52	18620.48	0.000
Kurtosis	1918.76	30.05	0.000

Outliers, extreme values in one or more variables, can distort statistics. Not all outliers have a significant impact, and caution is advised before removal (Goodwin & Leech, 2006). A few extreme values were noted, but on a Likert scale, these are likely representative responses. The analysis also checked for multivariate outliers. The Mahalanobis Distance and Cook's Distance metrics were calculated, indicating the presence of a few outlier cases (Table 5).

Table 5
Multivariate Outlier Test Result

Residuals Statistics	SA (40 Var)			
	Min	Max	Chi 0.001	N
Mahal. Distance	5.148	90.193	73.402	213
Cook's Distance	0.000	0.154		213

However, upon examination, these outlier cases align with the outliers identified in univariate screening. Moreover, their influence on predictor variables is minimal due to the acceptable value of Cook's distance. Therefore, it is reasonable to conclude that these outliers will not significantly affect the scores on variables. Furthermore, since the questionnaire was designed as an online survey where all the questions were mandatory, there was no possibility of a case of any missing data entry.

From above it could be concluded that the data seemed appropriate for further Exploratory Factor Analysis.

3.2 Exploratory Factor Analysis

The process involves a series of steps involving checking the appropriateness of data for EFA, selecting the factor analysis model and factor extraction method and finally deciding on the number of factors to be retained and the method of rotation to be employed (Watkins, 2021).

3.2.1 Data Appropriateness

Exploratory Factor Analysis (EFA) uses a correlation matrix for analysis, requiring sufficient covariance between variables. It is recommended to look for multiple correlations >=0.3 to assess the same (Hair et al., 2019; Tabachnick & Fidell, 2019). The two widely used comprehensive tests for data appropriateness for EFA are Bartlett's test of sphericity and the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy (Kaiser, 1974) with experts suggesting KMO values ≥ .60 while stressing for values ≥ .70 being preferable (Hoelzle & Meyer, 2012; Watson, 2017).

The visual examination of the correlation matrices shows significant correlations above 0.3. Bartlett's test of sphericity resulted in the rejection of the hypothesis that the correlation matrix was an identity matrix. The KMO measure yields acceptable results (overall model: .904; individual variables > 0.70 – Table 6). Therefore, collectively these metrics suggest that the correlation matrix is suitable for conducting exploratory factor analysis (EFA).

Table 6
KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.904
Bartlett's Test of Sphericity	Approx. Chi-Square	5341.453
	df	780
	Sig.	0.000

3.2.2 Factor Analysis Model

Principal Components Analysis (PCA) and Common Factor Analysis are the two models recommended by scholars for consideration. However, if the aim is to understand the underlying factors that cause the variables to manifest, Watkins (2021), citing Widaman (2018) argues that only CFA techniques should be used, not PCA. The CFA is also considered closer to real-life situations as the variance in the variables is bound to have some component of error variance (Finch, 2013; Haig et al., 2018). Therefore, a common factor model is chosen to meet this study's requirements.

3.2.3 Factor Extraction Method

The key distinction in extraction methods lies between Maximum Likelihood (ML) and least squares methods like ULS, GLS, and Principal Axis Factoring. ML hinges on assumptions of data randomness and multivariate normality, whereas least squares methods have no distributional assumptions (Fabrigar & Wegener, 2012).

In the section on data screening above, it was noted that though the variables in the data did follow univariate normality, the assumption of multivariate normality had to be rejected. Consequently, the ML method of extraction will not be appropriate, and a least square method of extraction (PA) is adopted. This is also in line with the suggestions of other researchers like Watson, (2017) who suggest that ML may be appropriate for data from large sample sizes exhibiting multivariate normality while principal axis factoring, a least square method, may be appropriate for smaller samples having non-normal data distribution.

3.2.4 Number of factors

Retaining an appropriate number of factors that are interpretable in a simple fashion is considered one of the most important decision steps in an EFA (Hoelzle & J. Meyer, 2012; B. G. Tabachnick & Fidell, 2019). It is recommended that empirical methods like Parallel Analysis; Minimum Average Partial (MAP) as well as theoretical insights must be used together for making this decision (Bandalos, 2018; Hair et al., 2019).

Table 7
Parallel Analysis

	Eigenvalues	
Factor	**Real**	**Random**
1	13.127	1.138
2	3.883	1.024
3	1.776	0.938
4	1.269	0.862
5	1.161	0.797
6	0.799	0.735
7	0.651	0.676
8	0.583	0.625

Table 8
MAP Analysis

The smallest average squared partial correlation is	0.0135
The smallest average 4rth power partial correlation is	0.0005
The Number of Components According to the Original (1976) MAP Test is	5
The Number of Components According to the Revised (2000) MAP Test is	5

The results from Parallel Analysis and initial EFA analysis in SPSS indicate (Tables 7 & 8) that retaining around five to six factors strikes an optimal balance between comprehensiveness and parsimony, aligning with empirical and theoretical considerations.

3.2.5 Rotation of Factors

EFA extraction prioritizes covariance among variables over factor interpretability, allowing for subsequent rotation to enhance loadings' interpretability (B. G. Tabachnick & Fidell, 2019). Rotation methods include orthogonal (yielding uncorrelated factors) and oblique (permitting factor correlations). While orthogonal rotations are preferred for their simplicity and ease of interpretation, oblique rotations are recommended due to their accuracy and to honour the reality that most variables are correlated to some extent (Bandalos & Finney, 2018). For their more realistic and statistically robust factor structures, oblique rotations are recommended for adoption in EFA (Watkins, 2021) and therefore, an oblique rotation is deemed appropriate for this study.

3.3 EFA Results

Forty variables were submitted to factor analysis using the above-mentioned methodology and parameters. Initially, no restriction was placed on the number of factors in the SPSS command and an initial solution was obtained. The factor loadings below 0.30 were suppressed in the analysis suggested by many researchers (Fabrigar et al., 1999; Gorsuch, 1983) as a common guideline for substantive interpretation. This was also within the approximate threshold value of 0.35 calculated using Norman's approximation method given by $\frac{5 \cdot 152}{\sqrt{N-2}}$ (Norman & Streine, 2014).

The initial solution suggested eight factors based on eigenvalues above 1.0 while explaining a total variance of 58%. However, there were variables with low intercorrelations and low loadings which made interpretation difficult. Six such variables were removed and EFA with the same parameters as before was run again on the remaining thirty-four attributes. There was no significant change in the KMO value after the removal of six variables mentioned above and it had slightly decreased from 0.904 to 0.902 while Bartlett's test of sphericity continued to be significant.

The revised solution consisted of six factors, which were in line with PA and MAP results, explaining 56% variance within the data set. The extracted factor solution is presented in Table 9 below.

Table 9
Final Factor Analysis Output

Success Attributes	Factor 1	2	3	4	5	6
SA12_Good Communication channels between PM and project team members	0.761					
SA15_Effective monitoring and feedback by PM	0.710					
SA13_Coordinating ability of PM with all stakeholders	0.685					
SA16_Timely decision-making by PM	0.591					
SA31_Adequate and clear communication between project team	0.527					
SA14_Ability of PM to delegate authority to team members	0.477					
SA17_Troubleshooting capability of PM	0.477					
SA41_Absence of conflict between project participants		0.699				
SA45_Mutual trust among project stakeholders		0.582				
SA4_Availability of resources throughout the project		0.544				
SA1_Detailed site investigation and site familiarity		0.489				
SA21_Quick and timely decisions by top management		0.467				
SA9_Adequate and timely funding from client		0.457				
SA2_Scope clearly and exhaustively defined			0.696			
SA6_Thorough understanding of scope by project manager			0.668			
SA7_Project Objectives clearly defined and understood by team			0.666			
SA5_Thorough understanding of scope by Contractor			0.558			
SA29_Clear and detailed change order processes			0.516			
SA8_Adequacy of plans and specifications			0.382			
SA32_Regular Quality control & quality assurance activities				0.706		
SA33_Regular control meetings between team members				0.699		
SA34_Adequate and efficient supervision at site				0.493		
SA23_Adequate training to develop critical skills of project team members				0.485		
SA36_Absence of bureaucracy in the project system				0.359		
SA19_Selection of competent project team by top management					-0.831	
SA20_Selection of PM with proven track record at an early stage by mgmt					-0.701	
SA11_Technical capability of Project Manager					-0.439	
SA18_Sufficient delegation of authority to PM for taking decisions at site					-0.383	
SA35_Experience and competence of contractors					-0.340	
SA37_Favourable working conditions at site						0.606
SA27_Efficient contractor selection criteria.						0.599
SA25_Appropriate risk appropriation between stakeholders						0.550
SA24_Adequate dispute resolution mechanisms in contract						0.499
SA26_Motivation and Incentives						0.326

The internal reliability of the extracted factors was checked (Table 10) using Cronbach's Alpha and values were found to be above 0.8 for all but one case (0.787) which is deemed to be above the acceptable value of 0.6 (DeVellis & Thorpe, 2021) confirming that the variables collectively share an underlying factor.

Table 10
Internal Reliability Assessment of Factors

Factor	No. of Items	Cronbach's Alpha (C_α)
Attributes in Factor 1	7	0.902
Attributes in Factor 2	6	0.787
Attributes in Factor 3	6	0.840
Attributes in Factor 4	5	0.813
Attributes in Factor 5	5	0.814
Attributes in Factor 6	5	0.803

4. Discussion on Critical Success Factors

For effective communication of the results of EFA, descriptive names that are characterized by the contents of each factor are given (Thomas G. Reio & Shuck, 2015). This section describes the interpretation and the naming of the extracted success factors.

Critical Success Factor 1-Competent Project Manager:

Seven measured variables, called attributes in the present case, loaded saliently onto Factor 1. All these variables seem to require a project manager's innate abilities and competence to manifest in a project scenario. For example, *maintaining good communication channels between PM and project team* members has been rated important and a competent project manager would ensure that these channels exist and are easy to access for two-way smooth communication to happen. *Effective monitoring and feedback* by a project manager is again a manifestation of the skill and competence of a project manager. A skilled and competent project manager ensures smooth and effective *coordination between all stakeholders* so that the scheduled works progress as per plan to ensure project success. He trusts his team to deliver by *delegating appropriate authority* to the team members and ensuring clear communication between the project team. A competent project manager makes *timely decisions* to avoid unnecessary delays and is adept at *troubleshooting problems* should they arise during the life cycle of the project. Therefore, CSF 1 aptly demonstrates the need to have a Competent Project Manager and is accordingly named so.

Critical Success Factor 2 - Proactive & Supportive Client:

Six measured variables loaded saliently onto Factor 2. The factor loadings ranged from a maximum of 0.699 to a minimum of 0.457. The variables in the factor indicate a common underlying property of a "proactive and supportive client" for ensuring the success of a project. A client supports the project by ensuring that there is *no conflict between the project participants*. A client puts in place an organizational structure that ensures *mutual trust* is always maintained among various project stakeholders. A supportive client helps the project achieve success by ensuring that required *resources are provided throughout the life cycle* of the project and the project does not suffer due to a lack of *timely funding*. Furthermore, a proactive client ensures that the project team is fully *familiar with the site* and possesses comprehensive site knowledge. They ensure *detailed and thorough site investigations* are carried out to prevent unexpected conditions that could impede progress later. They also establish efficient systems within the project ecosystem to enable *swift and timely decision-making by the project team's top management*.

Accordingly, Success Factor 2 named "*Proactive & Supportive Client*" is another critical success factor for ensuring project success.

Critical Success Factor 3 - Comprehensive Scope Definition:

Factor 3 exhibited significant loading with six measured variables. These loadings ranged from a maximum of 0.696 to a minimum of 0.382. An analysis of the structure matrix reveals that the factor accounts for 49% of the variance in the variables in the case of maximum loading and 26% in the case of the lowest loading. Within this factor, the variables collectively represent a shared underlying trait of having a detailed and well-defined scope. A detailed and well-defined scope is essential for ensuring project success. A well-defined and clear scope means that the *project objectives are clearly defined and understood* by all stakeholders so that all their efforts are directed at achieving a common goal. It also ensures that the main actors in the construction project viz *project manager, and the contractor understand the scope completely* so that the project planning occurs flawlessly and there are no surprises during project execution. A comprehensively defined scope ensures that the *plans, drawings, and specifications are correct* and *provide adequate requisite details* for all the works as envisaged in the scope while also laying out a *detailed process for processing any changes*, should they arise for any extraneous reason. This ensures that there are no cases of rework due to inadequacy or incorrectness of drawings or specifications. Therefore, this factor named "*Comprehensive Scope Definition*" correctly represents all the scope-related attributes that assist in ensuring the success of a construction project.

Critical Success Factor 4 - Effective and Detailed Quality Assurance Plan:

Five measured variables loaded prominently onto Factor 4. The factor loadings ranged from a maximum of 0.706 to a minimum of 0.359. Within this factor, the variables collectively signify an underlying construct linked to the necessity of a well-defined quality assurance plan (QAP) for the successful execution of a construction project. A comprehensive QAP provides explicit guidelines for *regular quality control and assurance activities*, along with a defined protocol for reviewing these activities through *regular control meetings*. It also ensures adherence to specified standards and quality requirements through *adequate and efficient site supervision*, reducing the likelihood of rework and potential delays. Additionally, a robust QAP emphasizes the need for *training and skill development among project team members* responsible for site supervision and QA activities. Efficient reporting and communication on quality matters are facilitated without *unnecessary bureaucratic obstacles*, allowing for swift issue resolution. Consequently, this critical success factor is aptly named "Effective and Detailed Quality Assurance Plan".

Critical Success Factor 5 - Competent Top Management:

Five measured variables loaded prominently onto Factor 5. The factor loadings ranged from a maximum of 0.831 to a minimum of 0.340. Within this factor, the variables collectively indicate an essential concept tied to the significance of having a capable and supportive top management. Competent top management contributes to project success by meticulously *selecting a proficient and capable project team* to oversee project execution. Additionally, they endorse project success by *appointing a project manager possessing the necessary technical expertise* and a *demonstrated track record* early in the project's lifecycle, ensuring their involvement in comprehensive planning.

Recognizing the importance of swift decision-making for timely project execution, competent top management *delegates ample authority to the project manager*, allowing them to make crucial site-based decisions promptly. Moreover, proficient top management also fosters project success by ensuring that only *experienced and competent contractors are selected*. Consequently, this vital success factor aptly bears the name "Competent Top Management".

Critical Success Factor 6 - Clarity & Suitability of Contracts:

On this factor, five measured variables loaded prominently with factor loadings ranging from a maximum of 0.606 to a minimum of 0.326. Within this factor, the variables collectively represent a shared underlying necessity of having a detailed and well-crafted contract for the project to proceed without any hurdles on account of problematic contract conditions. A well-crafted contract document goes a long way in not only minimizing the disputes that may arise but also incorporating such conditions which lead to healthy and *favourable working conditions* within the project environment for all stakeholders. *Appropriate risk appropriation between stakeholders* is one of the attributes of project success and it can manifest only through a well-defined contract. Similarly, a well-defined contract ensures that project claims are sorted efficiently and are not allowed to run into long-term disputes by incorporating appropriate clauses for *efficient and quick dispute resolution*. Furthermore, a well-drafted contract also fosters project success by incentivizing good and timely work of contractors through the inclusion of relevant clauses to boost *motivation*. Therefore, this important project success factor rightly bears the name "*Clarity & Suitability of Contracts*".

5. Ranking of Factors

In EFA, after factors are obtained, it should be the endeavour of the researcher to understand not only the magnitude of individual factors' contributions but also their relative significance in the overall system. In the context of the present research, this entails finding which factor among the six success factors has the most impact on the project's success. Summated scores enable a researcher to deploy a large number of statistical tools such as the Relative Importance Index (RII) and Analysis of Variance (ANOVA) effectively (Stevens, 2002). As illustrated by B. Tabachnick & Fidell, (2013), the summated scores are calculated by adding the individual's responses on the items or variables that fall within a factor.

RII is presumed to be an appropriate tool to use over simple averages and standard deviation for ranking purposes due to the former's ability to account for the subtle relative importance of factors within the overall system while the latter might treat all factors equally (Iyer & Jha, 2006; Kumaraswamy & Chan, 1998). Consequently, RII is used for ranking the extracted critical success factors.

The Relative Importance Index (RII) is calculated using the following formula:

$$\text{RIIi} = \frac{\sum(W_i \times X_i)}{N \times H_i}$$

where:

- RII_i is the Relative Importance Index for factor i.
- W_i is the weight assigned to factor i.
- X_i is the mean score of factor i.
- N is the number of factors being considered.
- H_i is the highest possible score for factor i (e.g., the maximum score on the scale used for that factor).

Since summated scores are used in this analysis, the product $W_i \times X_i$ needs to be derived from data by finding out the summated factor scores in a particular Factor for all respondents and multiplying the same with the frequency of such scores. The highest possible factor score will be the highest rating possible for a variable, which is 5, multiplied by the number of measured variables loading in a particular factor.

Table 11
Ranking of Factors as per RII

Critical Success Factors	Total Responses	Highest Possible Score for Factor	Weighted Total Score	Relative Importance Index (RII)	Mean Score	Rank
	N	H	W	W/(N × H)	W/N	
CSF 1:Competent Project Manager	213	35	5648	0.758	26.516	3
CSF 2:Proactive & Supportive Client	213	30	5457	0.854	25.620	1
CSF 3:Comprehensive Scope Definition	213	30	4868	0.762	22.854	2
CSF 4:Effective and Detailed Quality Assurance Plan	213	25	3783	0.710	17.761	5
CSF 5:Competent Top Management	213	25	4016	0.754	18.854	4
CSF 6:Clarity and Suitability of Contracts	213	25	3493	0.656	16.399	6

RII thus calculated is presented in Table 11. It can be observed that the most influential factor for a project to succeed, as indicated by the highest RII, is having a *proactive and supportive client*. This suggests that stakeholders recognize the substantial impact a client can have on the success of a construction project. It is also worthwhile to note that this factor ranks 2nd in terms of average score and not 1st. This indicates that though this factor may not be commonly reported it is considered extremely important by those who report it meaning that this factor could be having a substantial impact on the project outcome, even though it may not be widespread.

Comprehensive Scope Definition follows as the second most important CSF signifying alignment with industry best practices that emphasize the important role that a clear project scope plays in project management. '*Competent Project Manager'* is identified as the third most critical factor. What is noteworthy in this factor is the fact that it receives the highest average score which signifies that a large no of stakeholders acknowledge that this is an important factor to be considered in project success but the experts who report the first two CSFs mentioned above attached a very high degree of importance to these two when compared to Competent Project Manager as CSF. This is an important result as it points out the importance of client engagement and his due diligence in framing the project over that of having a competent project manager. This should be intuitive too as having an excellent team will only work if the working conditions and project ecosystem are conducive for it to deliver results.

Competent Top Management follows closely in importance followed by *Effective and Detailed Quality Assurance Plan* as the fifth critical success factor. This highlights the emphasis on maintaining high standards of quality throughout the project lifecycle.

Lastly, while still important, *Clarity and suitability of Contracts* is perceived as the least critical among the identified success factors. This does not diminish its importance but rather suggests that other factors such as client engagement, project scope, and competent leadership hold greater sway in determining project success.

6. Validity Across Groups

This study aims to identify critical success factors in the current construction sector across the country. Before the results can be reported as generalized, it is necessary to examine the potential disparities in assessments among different professional roles (clients, contractors, and consultants) and evaluate regional variations in project evaluations across the country.

Analysis of Variance (ANOVA) has been widely utilized in similar studies to detect significant variations across categorical groups (De Smith, 2015; Montgomery et al., 2021), as it is considered a robust tool for comprehensive assessment of potential differences (Hair, 2009) rendering it an appropriate choice for the current exercise.

The summated scores of CSF1 to CSF6 are the variables, while as *role* is selected as the categorical variable, homogeneity of variance was checked using the Levine statistic. The test was not significant for the first five variables at an alpha level of 0.05 signifying a valid assumption of homogeneity of variances for these variables. However, for the sixth variable (CSF 6), Levine's test statistic was significant (p=0.022) and consequently, one-way ANOVA may not be the most appropriate method for analyzing this variable, and a non-parametric test was employed instead to find out if there are any significant differences in responses between the categorical groups, that is, Clients, Consultants and Contractors.

The results of one-way ANOVA carried out in SPSS for variable CSF 1 to CSF 5 with *Role* as grouping variable is presented in Table 12.

Table 12
ANOVA Results of CSFs with "Role" as the grouping variable

Variables	Sum of Squares	df	Mean Square	F	Sig.
CSF 1: Competent Project Manager	122.67	2	61.336	3.97	0.02
CSF 2: Proactive & Supportive Client	44.798	2	22.399	2.18	0.12
CSF 3: Comprehensive Scope Definition	19.952	2	9.976	0.83	0.44
CSF 4: Effective and Detailed Quality Assurance Plan	29.573	2	14.787	2.08	0.13
CSF 5: Competent Top Management	13.307	2	6.654	0.95	0.39

It can be observed that the p-value for all variables except for variable CSF 1 is more than the significance value of 0.05, requiring retaining the null hypothesis of similar distributions, meaning thereby that there is no significant difference in scores between the responses of Clients, Consultants and Contractors on critical success factors CSF 2, CSF 3, CSF 4, CSF 5. The non-parametric Kruskal-Wallis test on variable CSF 6 is also not significant (Table 13) and suggests that there is no significant difference in score on this variable within the groups.

Table 13
Kruskal Wallis Test Results for CSF 6

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of CSF 6: Clarity and Suitability of Contracts is the same across categories of Role.	Independent-Samples Kruskal-Wallis Test	0.649	Retain the null hypothesis.

A significant p-value of 0.02 for CSF 1 in the ANOVA test indicates that there is some difference between the mean summated scores on this critical success factor across categories of '*Role*'. Accordingly, to find which group differed significantly, post hoc Gabriel's test was conducted. Gabriel's test is often preferred over Tukey's HSD in cases with unequal sample sizes because Tukey's HSD relies more on the assumption of equal sample sizes and homogeneity of variance (Bretz et al., 2010). A p-value = 0.037 which is significant at an alpha value of 0.05 signifies that there is some difference between the scores given by Clients against those given by the Consultants for this success factor.

Table 14
Post-Hoc Analysis for CSF 1

Dependent Variable			Mean Difference	Std. Error	Sig.	95% Confidence Interval	
						Lower	Upper
CSF 1: Competent Project Manager	Client/Owner	Contractor	-0.21601	0.74669	0.988	-2.0123	1.5803
		Consultant	-1.61427*	0.64622	0.037	-3.1542	-0.0744
	Contractor	Client/Owner	0.21601	0.74669	0.988	-1.5803	2.0123
		Consultant	-1.39826	0.66536	0.100	-2.9786	0.1821
	Consultant	Client/Owner	1.61427*	0.64622	0.037	0.0744	3.1542
		Contractor	1.39826	0.66536	0.100	-0.1821	2.9786

However, the homogenous subsets in SPSS output for this factor show only one subset for all three group means at 0.05 alpha level. This indicates that though there is some difference between the groups, it is not significant enough to warrant a separate subset.

Table 15
Homogeneous Subsets for CSF1

CSF 1:Competent Project Manager		
Role	N	Subset for alpha = 0.05
		1
Client/Owner	58	25.6897
Contractor	53	25.9057
Consultant	102	27.3039
Sig.		0.058

Thus, it can be concluded that the scores on all six success factors are the same across the three categories. This means that the perceived importance of the critical success factors remains consistent across the different *Role* categories (Clients, Consultants, and Contractors). The findings highlight that all three main project proponents unanimously agree on what are the most critical factors in order of their importance for the success of a construction project in the Indian context.

Using a similar process as described above but utilizing "Geography" as a categorical variable, an examination of Critical Success Factors (CSFs) was undertaken to assess potential regional disparities in project evaluations. The findings indicate that there are no apparent variations in the assessments of Critical Success Factors across the diverse geographical regions of India.

From above it can be concluded that the perception of experts on the importance of critical success factors across various roles as well as geographies within the country are consistent.

7. Conclusion

Statistical analysis of the survey responses based on the forty-five success attributes collected from the literature revealed six critical success factors as the underlying constructs driving the success attributes generally considered prevalent in construction projects. These factors are *Competent Project Manager*, *Proactive & Supportive Client, Comprehensive Scope Definition, Effective and Detailed Quality Assurance Plan, Competent Top Management* and *Clarity & Suitability of Contracts.* It proved intriguing to discover that attributes such as technological interventions and high automation in project execution and planning, included in the questionnaire to reflect the contemporary project ecosystem, were deemed unimportant by respondents. This suggests that the indicators of performance and tools for achieving it have not undergone significant changes over time.

The study revealed that having a *proactive and supportive client* was recognised by all the stakeholders as the most impactful factor for a successful project suggesting that stakeholders recognize the substantial impact a client can have on the success of a construction project. This is followed closely by the need for a *Comprehensive Scope Definition.* Having a *Competent Project Manager* is identified as the third most critical factor underscoring the significance of having an adept project manager at the helm, capable of orchestrating various aspects of the project from planning to execution. A worthwhile result evidenced by the study is that though 'Competent Project Manager' has an RRI ranking of 3, it has the highest rating on an average score basis signifying that this factor is generally ubiquitous in the project management ecosystem and yet its impact is not perceived as critical as having a proactive and supportive client by the experts. Conversely, due to a low average score but highest RII ranking, the factor of *proactive and supportive client* may not be commonly reported or prevalent among the respondents, it is considered extremely important by those who report it indicating that this factor could be having a substantial impact on the project outcome, even though it may not be widespread. While *Competent Top Management* follows at the fourth position, *Effective and Detailed Quality Assurance Plan* is identified as the fifth critical success factor. Lastly, while still important, *Clarity and suitability of Contracts* is perceived as the least critical among the identified success factors.

The study also indicates that the assessments of the critical success factors do not exhibit significant differences across roles and geographic locations thereby signifying unified perspectives among experts.

The identification of critical success factors in this paper is part of an ongoing research initiative. The overarching goal is to explore the correlation between critical success factors and critical delay factors in projects in India. The research aims to assess how critical success factors contribute to controlling factors that lead to delays. Though the assessments in the study are driven by the research carried out in India, the findings possess a global appeal, offering replicable insights that can be adapted elsewhere while incorporating the local nuances inherent in diverse project environments, utilizing the methodology outlined in the paper.

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