Examining the Factors Affecting Building Rehabilitation Projects in India through Confirmatory Factor Analysis

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Abstract—In India, a high-performance building rehabilitation package must be implemented more quickly in order to achieve the country's sustainable development objective. In order to attain this degree of performance, the construction method for building rehabilitation should move towards industrialized solutions that take into account all construction stakeholders' demands and are unencumbered by current industrial problems. The aim of this study is to investigate and evaluate the fundamental elements and the corresponding challenges that impact building rehabilitation initiatives in India. The purpose of this research is to furnish important insights to the project's stakeholders, empowering them to anticipate and prepare for possible obstacles. While conducting a secondary survey 25 underlying challenges were identified for the execution of building rehabilitation projects in India. The research method involved the study of 38 buildings in the National Capital Region (NCR) to verify and validate these challenges through detailed stakeholder discussion and interviews. The study was analyzed using Confirmatory Factor Analysis (Structure Equation Modelling) using Smart PLS at 0.90 Cronbach's alpha reliability value of the data collected using a questionnaire survey. Further, four significant factors were confirmed at KMO= 0.90. The challenges are grouped under four factors, Project Definition; Project Procurement; Project Risk Management, and Project Closure and Handover. The result shows that factors analyzed and presented significantly exist at the rehabilitation sites.

Keywords: Building Rehabilitation, Service Life, Confirmatory Factor Analysis

INTRODUCTION

Building rehabilitation Project involves the process of repairing, altering, or adding to a deteriorating building to make it compatible for use. As per (GoI-UNDP Disaster, 2007) "Rehabilitation denotes repairing buildings damaged during service or by earthquakes without upgrading the seismic resistance." It is conceivable that rehabilitation could substantially improve and reinforce aspects such as the lifespan of building services, the quality of the living environment, property valuations, and the city's overall image (Hui & Lau, 2011). Financial aspects tend to tip the balance towards building rehabilitation rather than demolition and new construction (Laure & Klunder, 2007), except in those cases where the building is so damaged that rehabilitation costs reach the levels of new construction costs.

A Project is considered as a successful project when it is completed on time, within budget & to performance specification (Juneja, & Dubey, 2018). Various attempts have been made globally by different researchers to determine critical success factors in construction. There are some variables common to more than one list, but there are certainly no general agreement on the variables (Chan & Tam, 2000). Critical success factors ensure success of a manager or an organization that must be given special and continual attention to bring about high performance (Srimathi *et al.,* 2017). This research aimed to analyse and evaluate the factors affecting the success of Building Rehabilitation Projects in India. Need of the study emerged from the premise that rehabilitation projects require in-depth assessments and meticulous planning to ascertain the extent of rehabilitation needed. Such complexity is rarely encountered in greenfield projects (Ghanaee & Pourezzat, 2013). The frequent occurrence of inadequacies and setbacks in rehabilitation projects necessitates a dedicated effort to identify and understand the root causes of failures (Peng, 2017). The current study delves into rehabilitation projects in India, focusing on understanding the factors influencing their success or failure. Through an in-depth exploration, this study contributes to the comprehension of rehabilitation project dynamics, moving beyond identification to establish the authenticity of factors associated with project failures in the Indian context.

Building rehabilitation Project involves the process of repairing, altering, or adding to a deteriorating building to make it compatible for use. The revitalization of aging urban areas through building rehabilitation is a vital component in fostering sustainability within our cities, offering a cost-effective approach. (Hui *et al.,* 2008) says although buildings do not possess an infinite economic lifespan, the gradual decay of their fabric and structure can be mitigated through the execution of repair and maintenance initiatives.

In the domain of building rehabilitation, a fact emerges as occurrence of the high degree of project failures. A Project is considered as a successful project when it is completed on time, within budget & to performance specification (Juneja & Dubey, 2018). The causes behind an unsuccessful project may vary by the type of project being studied. Distinctive patterns of causes may be associated with the unsuccessfulness of specific types of projects (Pinto & Mantel, 1990). The Project Management Book of Knowledge (PMBOK, 2017), defines the success or failure of a project based on the disparity between what is anticipated from the project both during its execution and after its completion and the actual performance of the project when it is utilized.

Many scholars and construction professionals have been drawn to investigating the factors that can impact the outcome of infrastructure projects over the years. In a study by (Khan *et al.,* 2021) various challenges were identified which are faced in repairs and rehabilitation of dilapidated buildings. The major reasons were Identified as lack of specialization in construction techniques, inefficient resource planning & inefficient project planning & management. Various reasons for delay of rehabilitation projects were identified by (Khatib *et al.,* 2020) as inadequate finance, lack of skilled labour, inefficient project planning & management, inadequate material procurement planning & management, inefficient site management, lack of qualified and experienced personnel, ineffective contract administration, site restrictions & conditions, improper design.

Failure attributes in building projects represent distinct characteristics that indicate deficiencies or inadequacies in the planning, execution, or completion of these endeavours. These attributes are crucial for shedding light on the factors contributing to project failures and facilitating a deeper comprehension of why these initiatives often fall short of their intended success parameters. A significant number of Failure attributes have been identified in this study through extensive literature study Annexure-1.

FACTOR IDENTIFICATION

Thematic analysis was employed to comprehensively examine the failure attributes identified from the existing literature. By discerning commonalities and resemblances among these attributes within the literature, the study ultimately identified four pivotal factors: Project Definition, Project Contract Management, Project Risk Management, and Project Handover, as illustrated in Figure 1 & 2.

PROJECT DEFINITION

The attributes grouped under this factor collectively provide essential information of scope of the overall project. The collective significance of these attributes lies in their role in shaping the project's foundation and ensuring that it is well-defined, feasible, and aligned with its objectives (Doraisamy *et al.,* 2015). Hence, this factor is named as "Project Definition".

PROJECT CONTRACT MANAGEMENT

Project Contract Type indicates the type or nature of contracts employed in the project. It plays a pivotal role in defining the legal and financial framework of the project (Omran *et al.,* 2012), whether it involves fixed-price contracts, cost-plus contracts, or other contractual arrangements. Procurement procedures are essential in outlining how goods and services are sourced, purchased, and managed within the project (Fantazi *et al.,* 2019). This attribute pertains to how subcontractors are monitored, supervised, and coordinated to ensure they meet project requirements and timelines (Omran *et al.,* 2012).

They offer insights into the strategies, procedures, and practices employed to effectively manage contracts, which is vital for ensuring that contractual agreements are upheld and that the project progresses smoothly within the established contractual framework (Doraisamy *et al.,* 2015). Hence, this factor is named as "Project Contract Management".

PROJECT RISK MANAGEMENT

Risk Identification pertains to the process of identifying potential risks or uncertainties that may impact the project. Quality Assurance (QA) and Quality Control (QC) processes are vital for ensuring that specialized work within the project meets defined quality standards (Hui *et al.,* 2008). Effective risk management involves systematic procedures for assessing, mitigating, and monitoring risks throughout the project's lifecycle (Shah *et al.,* 2021). This attribute delves into the strategies and methodologies employed to manage and minimize project risks. Change management processes are essential for handling alterations or modifications within the project (Naaranoja & Uden, 2007). Effective management practices are crucial for overseeing project activities and ensuring smooth operations. Communication plays a vital role in risk mitigation (Fantazi *et al.,* 2019).

The cluster of attributes falling under the third factor is closely associated with the management of risks within the project. These attributes collectively offer insights into various aspects of risk identification, mitigation, and management practices that are essential for effective project execution (Juneja, & Dubey, 2018). Hence, the third factor was named as "Project Risk Management".

PROJECT HANDOVER

The attributes grouped under this category offers insights into the critical phase of transitioning from construction or implementation to the operational use of the project highlighting the importance of assessing project success, evaluating its performance post-occupancy, and conducting functional testing to ensure its intended functionality (Peng, 2017).

DATA COLLECTION

QUESTIONNAIRE SURVEY

The initial pilot study conducted subsequent to a thorough literature review, involved structured interviews with industry participants. The professionals who participated in the pilot survey had more than 15 years of working experience in construction projects. Following the pilot study, refinements were made to the questionnaire based on the feedback received. To select the case study samples, the researchers approached various stakeholders, including clients, professional, and contractors operating in the New Delhi region. Table-2 provides information about 30 different case studies of different rehabilitation sites in the New Delhi region approached for this study.

The questionnaire was in a Close Ended Format. This questionnaire which had 25 key attributes was crafted based on the inputs from the pilot study. To measure the impact of these attributes, a 5-point Likert scale was employed, a widely recognized tool for assessing individuals' attitudes, opinions, or perceptions.

SAMPLE SIZE

The survey was circulated amongst the various stakeholders of the identified sites. A total of 198 samples were collected. This sample size satisfies the minimum ratio of items to respondents (ratio of 1 : 5) for carrying out factor analysis (Hair, 2009). Sample size can also be calculated by Cochran's equation. It was found out that the sample size should be 203, which was rounded up to 200. So, the sample size taken was adequate as per Cochran's equation.

DATA ANALYSIS THROUGH SMART PLS SEM

CFA was performed using SEM as implemented in PLS to test the theoretical model's reliability and validity as shown in Figure 1. PLS path model (drawn in Smart PLS software) after PLS Algorithm calculation with independent variables (failure attributes), dependent variable (latent factors), the relationship among variables and all indicators of variables are shown in Figure 2.
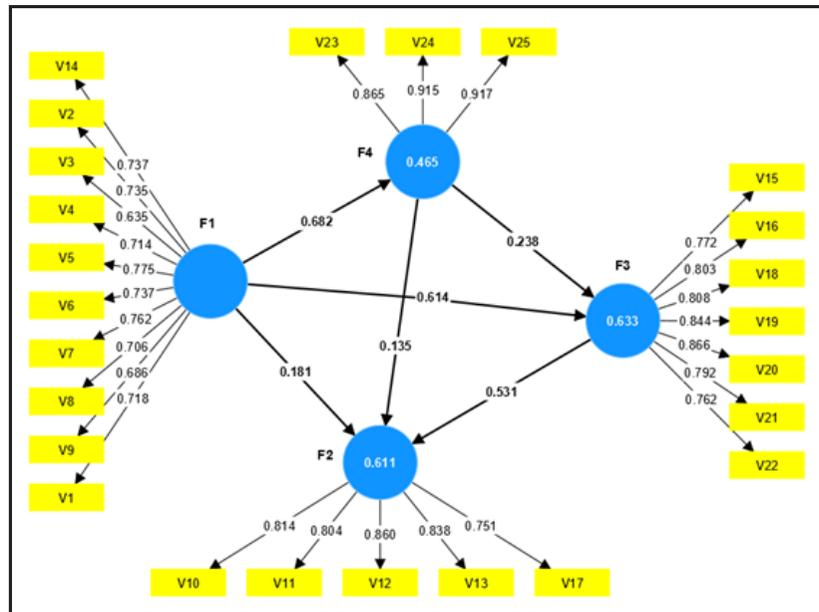
Fig.1: Study Model (*Source:* Author)

INDIVIDUAL ITEM RELIABILITY AND CONVERGENT VALIDITY

The convergent validity of each latent construct was assessed in the context of Partial Least Squares Structural Equation Modeling (PLS-SEM) by comparing the values of the average variance extracted (AVE), composite reliability (CR) scores, and Cronbach's alpha coefficient to predetermined thresholds of 0.70, 0.70, and 0.50, respectively (Hair *et al.,* 2011) and (Wong, 2013) Cronbach's alpha & Composite reliability should be higher than 0.70 and AVE should be higher than 0.50. Table 1 demonstrates that all reflective constructs exceeded these threshold values.

As per (Hair *et al.,* 2011) and (Wong, 2013) Outer loadings should be higher than 0.70. In Table 2, it is evident that the outer loadings for all items exceeded the 0.7 threshold, except for V3 and V9. However, as per (Mehta, 2022) these specific items were retained due to considerations related to content validity. In summary, the measurement scales demonstrate strong convergent validity and internal consistency overall.

MEASUREMENT MODEL

The evaluation of a measurement model relies on the premise that if there is uncertainty about whether the measures accurately reflect the intended constructs, it is not advisable to employ them to analyze the structural relationships (Hair *et al.*, 2011) (Wong, 2013).

Table1: Individual Item Reliability and Convergent Validity Values (*Source:* Author, 2023)

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Project Definition **(F1)**	0.897	0.901	0.915	0.52
Project Contract Management **(F2)**	0.872	0.873	0.908	0.663
Project Risk Management **(F3)**	0.911	0.912	0.929	0.652
Project Handover **(F4)**	0.881	0.881	0.927	0.809

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Table 2: Outer Loading Values (*Source*: Author, 2023)

Failure Attributes	Project Contract Management	Project Definition	Project Handover	Project Risk Management
V10		0.814		
V11		0.804		
V12		0.86		
V13		0.838		
V14	0.737			
V15			0.772	
V16			0.803	
V17		0.751		
V18			0.808	
V19			0.844	
V2	0.735			
V20			0.866	
V21			0.792	
V22			0.762	
V23				0.865
V24				0.915
V25				0.917
V3	0.635			
V4	0.714			
V5	0.775			
V6	0.737			
V7	0.762			
V8	0.706			
V9	0.686			
V1	0.718			

DISCRIMINANT VALIDITY

The analysis findings are displayed in Tables 3 and 4. (Fornell & Larcker, 1981) if the square root of the AVE in each latent variable has a higher correlation value than other values among the latent variables, this can be utilized to show discriminant validity. Table 4 reveals that the Fornell Larcker criteria of the diagonal elements to be the highest value is fulfilled. Similarly, in HeterotraitMonotrait Ratio (HTMT) is a measure of similarity between the latent variable. As per (Hair *et al.,* 2011) and (Wong, 2013) HTMT values should be less than 0.85. In Table 5, it is evident the HTMT values are less than the threshold limit of 0.85. Consequently, these observations indicate that there are no issues concerning discriminant validity.

STRUCTURAL MODEL

The structural model represents the relationship between latent variables hypothesized in the research model (Rahman *et al.,* 2015). The R2 values and the degree of significance of the path coefficients, which explained the variance of endogenous latent variables, were the primary evaluation criteria for the structural model. (Hair *et al.,* 2011).

COLLINEARITY STATISTICS

To determine redundancy, researchers should examine the degree of multicollinearity in the formative indicators (Cassel *et al.,* 1999; Grewal *et al.,* 2004). As a rule of thumb, researchers need to have a VIF of 5 or lower (i.e., Tolerance

level of 0.2 or higher) to avoid the collinearity problem (Hair *et al.,* 2011). Table 5 shows that all VIF scores were less than the threshold of 5.

Path Coefficients, R-Square & f-Square

PLS-SEM does not presume that the data are normally distributed. In order to get standard errors for hypothesis testing, PLS uses nonparametric bootstrapping, which is repeated random sampling with replacement from the original sample to construct a bootstrap sample. It is possible to assess the significance of the computed coefficients in PLS-SEM thanks to the bootstrap sample (Henseler, 2017). According to Hair *et al.* (2011), there should be 5000 bootstrap "samples" and the same number of bootstrap "cases" as there are valid observations. Using 5000 samples, this study ran a bootstrap analysis in Smart PLS. The analysis result in Table 6 shows the P-values which are less than 0.05 which indicates that the next step can be followed.

The coefficients of the PLS structural version may be interpreted as standardized beta coefficients of least squares regressions. Paths that are nonsignificant or display symptoms and symptoms opposite to the hypothesized course no longer guide a previous hypothesis, while extensive paths displaying the hypothesized course empirically guide the proposed causal relationship (Hair *et al.*, 2011). Table 7 indicates that zero isn't always protected withinside the bias corrected that means that the course coefficient is extensive.

According to (Hair *et al.*, 2011), an R^2 value between 0.02 - 0.12 is weak, 0.13 - 0.25 is moderate, and 0.26 & above is substantial. Table 8 specifies the values of R^2, which are substantial explaining the variance in the endogenous variable explained by the exogenous variables. The Cohen's Indicator (f^2) is obtained by the inclusion and exclusion of model constructs (one by one). Values of 0.02, 0.15 and 0.35 are considered small, medium, and large respectively (Hair *et al.*, 2011). Table 9 shows the f^2 values.

Table 3: Fornell Larcker Criterion (*Source:* Author, 2023)

	Project Definition (F1)	Project Contract Management (F2)	Project Risk Management (F3)	Project Handover (F4)
Project Definition (F1)	0.776			
Project Contract Management (F2)	0.686	0.814		
Project Risk Management (F3)	0.721	0.761	0.808	
Project Handover (F4)	0.682	0.607	0.656	0.899

Table 4: Heterotrait Monotrait Ratio (HTMT) (*Source:* Author, 2023)

	Project Definition (F1)	Project Contract Management (F2)	Project Risk Management (F3)	Project Handover (F4)
Project Definition (F1)				
Project Contract Management (F2)	0.767			
Project Risk Management (F3)	0.849	0.848		
Project Handover (F4)	0.765	0.687	0.732	

Table 5: Variance Inflation Factor (VIF) values of Outer Model (Source: Author, 2023)

V10	V11	V12	V13	V14	V15	V16	V17	V18	V19
2.144	2.122	2.608	2.368	1.842	1.944	2.195	1.556	2.184	2.795

V2	V20	V21	V22	V23	V24	V25	V3	V4	V5
2.444	3.15	2.219	1.97	2.02	2.989	2.944	1.76	1.878	2.14

V6	V7	V8	V9	V1					
1.916	2.021	1.841	1.706	2.244					

Table 6: Path Coefficients-Mean, Std Dev, T-value, P-value (*Source:* Author, 2023)

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
F1 -> F2	0.181	0.188	0.081	2.236	0.025
F1 -> F3	0.614	0.619	0.058	10.518	0
F1 -> F4	0.682	0.683	0.042	16.072	0
F3 -> F2	0.531	0.527	0.085	6.265	0
F4 -> F2	0.135	0.133	0.078	1.731	0.044
F4 -> F3	0.238	0.234	0.062	3.815	0

Table 7: Path Coefficients-Confidence Interval bias corrected (*Source:* Author, 2023)

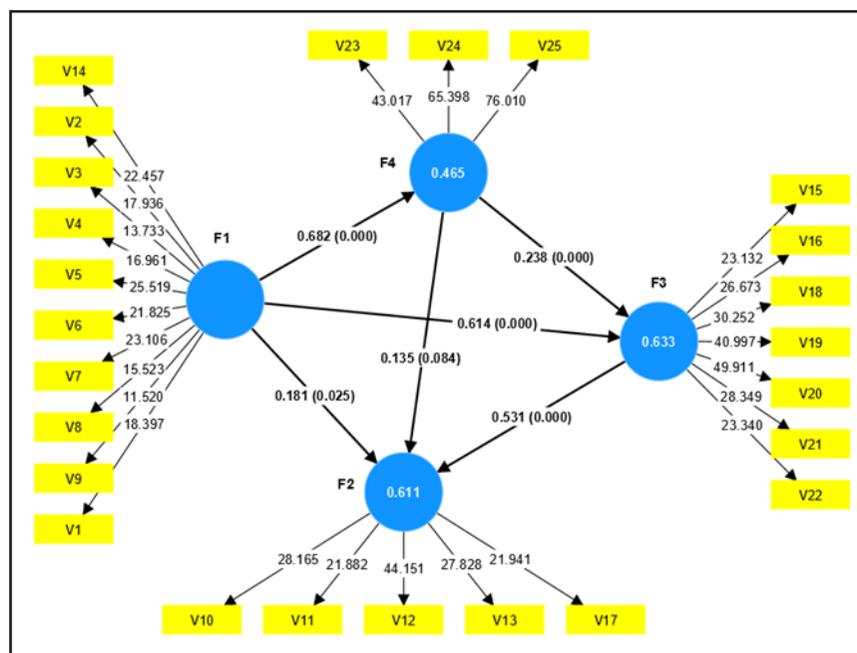|	Original sample (O)	Sample mean (M)	Bias	2.50%	97.50%
F1 -> F2	0.181	0.188	0.006	0.026	0.34
F1 -> F3	0.614	0.619	0.004	0.494	0.724
F1 -> F4	0.682	0.683	0.001	0.583	0.753
F3 -> F2	0.531	0.527	-0.004	0.354	0.69
F4 -> F2	0.135	0.133	-0.002	-0.019	0.285
F4 -> F3	0.238	0.234	-0.004	0.116	0.363

Fig. 2: Study Model After Bootstrapping (*Source:* Author, 2023)

Table 8: R-Square overview (*Source:* Author, 2023)

	R-square	R-square adjusted
F2	0.611	0.604
F3	0.633	0.629
F4	0.465	0.462

Table 9: f-Square (*Source:* Author, 2023)

	F1	F2	F3	F4
F1		0.029	0.55	0.868
F2				
F3		0.266		
F4		0.023	0.082	

Table 10: f-Square (*Source:* Author, 2023)

	Saturated model	Estimated model
SRMR	0.063	0.063
d_ULS	1.301	1.301
d_G	0.63	0.63
Chi-square	618.434	618.434
NFI	0.809	0.809

MODEL FIT INDICES

The The analysis findings are displayed in Tables 10. The value of the SRMR was below the recommended threshold value of 0.080 (Benitez *et al.,* 2020) which indicates it has less residual error. The NFI value is nearer to 0.9. All these indices indicate that the model is fit and good.

DISCUSSION

The research has substantiated the conjecture that success in rehabilitation projects hinges on the strategic consideration of four pivotal factors: Project Definition, Project Contract Management, Project Risk Management, and Project Handover. Undoubtedly, these elements play a crucial role in shaping the outcome of rehabilitation initiatives. Nevertheless, it is imperative to recognize and address the inherent limitations of the study. Notably, the data collection process for the survey was confined to the geographical confines of the National Capital Region (NCR) in India. While this localized approach offers valuable insights, it falls short of providing a comprehensive understanding applicable across the entire country. To enhance the robustness and applicability of the findings on a broader scale, it is imperative to engage in a more expansive and inclusive data collection effort, spanning diverse regions of the country. Such a comprehensive approach ensures not only cross-cultural validation but also facilitates the generalization of the study's conclusions to a more representative and diverse spectrum of the population, thereby encouraging the overall credibility and relevance of the research outcomes.

CONCLUSION

In the context of Building Rehabilitation projects , the achievement of success is a multifaceted and intricate undertaking, characterized by numerous factors and considerations. A clear project definition lays the groundwork for a well-defined scope, and effective contract management ensures the adherence to agreements. Proactive risk management helps mitigate uncertainties, and thorough handover and post-occupancy evaluations guarantee the fulfilment of project objectives. This research has expanded the understanding of these factors and their profound impact on the success of building rehabilitation projects in Indian context. Construction project managers

and stakeholders should be exceptionally attentive to these factors and attributes. Recognizing their significance and integrating them into project planning and execution processes is imperative for attaining successful outcomes within the intricate and evolving landscape of building rehabilitation projects. A comprehensive approach to addressing these factors empowers stakeholders to navigate challenges, mitigate risks, and enhance the prospects of successfully completing projects with enduring functionality.

FUTURE SCOPE

A comprehensive exploration is undertaken to elucidate the potential avenues for future research endeavours within the purview of this particular subject matter. The attributes/ challenges linked with the identified factors were identified in the current research. Future scope of this study will be to further study in depth the challenges identified by the researcher and propose mitigation strategies for the same. The research approach adopted for the mitigation strategies can be a theoretical approach as the research will involve refining a particular theory and improve an action.

CONFLICTS OF INTEREST

No conflict of interest was declared by the authors.

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