Determining success factors and barriers for Electronic Document Management System in the Indian construction industry.

Submitted By

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DEPARTMENT OF CIVIL ENGINEERING

INSTITUTE OF TECHNOLOGY

NIRMA UNIVERSITY

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Determining success factors and barriers for Electronic Document Management System in the Indian construction industry.

Major Project

Submitted in partial fulfillment of the requirements

for the degree of

Master of Technology in Construction Technology and Management

Submitted By

Takshal Jagdishbhai Prajapati

(22MCLT13)

Guided By

Dr.Vishal Lad

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May 2024

Certificate

This is to certify that the major project entitled **"Determining success factors and barriers for Electronic Document Management System in the Indian construction industry."** submitted by **Takshal Jagdishbhai Prajapati (22MCLT13)**, towards the partial fulfillment of the requirements for the award of the degree of Master of Technology in Construction Technology and Management of Nirma University, Ahmedabad, is the record of work carried out by him under my supervision and guidance. In my opinion, the submitted work has reached the level required for being accepted for examination. The results embodied in this major project, to the best of my knowledge, haven't been submitted to any other university or institution for the award of any degree or diploma.

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Statement of Originality

I, **Takshal Jagdishbhai Prajapati**, Roll. No. **22MCLT13**, give undertaking that the Major Project entitled "**Determining success factors and barriers for Electronic Document Management System in the Indian construction industry.**" submitted by me, towards the partial fulfillment of the requirements for the degree of Master of Technology in **Construction Technology and Management** from Civil engineering department of Institute of Technology, Nirma University, Ahmedabad, contains no material that has been awarded for any degree or diploma in any university or school in any territory to the best of my knowledge. It is the original work carried out by me and I give assurance that no attempt of plagiarism has been made.It contains no material that is previously published or written, except where reference has been made. I understand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere; it will result in severe disciplinary action.

____

Signature of Student
Date:
Place:

Endorsed by
Dr.Vishal Lad
(Signature of Guide)

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Abstract

The construction industry is often regarded as fragmented, inefficient, and underperforming. To address these issues, Electronic Document Management Systems (EDMS) have been implemented. However, the adoption of EDMS in the Indian construction sector, particularly among Small and Medium-sized Enterprises (SMEs), faces significant challenges due to organizational and technological constraints. This research aims to identify the success and barrier factors affecting EDMS implementation in Indian construction SMEs. The study synthesizes various literature reviews to identify 15 success attributes and 7 barrier attributes. A comprehensive questionnaire survey was conducted to collect data, which was then analyzed using Exploratory Factor Analysis (EFA) with SPSS software. Following EFA, Confirmatory Factor Analysis (CFA) was performed, leading to the development of a hypothesized model using Structural Equation Modeling (SEM) with AMOS software. The findings provide critical insights into the factors that influence the successful implementation of EDMS in the Indian construction industry, offering a valuable resource for SMEs aiming to improve their document management practices and overall efficiency.

Abbreviations

EDMS	Electronic Document Management System.
SMEs	Small and Medium Enterprises.
EFA	Exploratory Factor Analysis.
CFA	Confirmatory Factor Analysis.
SPSS	Statistical Package for Social Sciences.
AMOS	Analysis of Moment Structures
FS	Front Side
BS	Back Side

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Chapter 1

Introduction

1.1 Prologue:

The main pillars of the construction industry are time, cost, quality, and trust. Regarding this, operational efficiency in time and quality generates money, while dedication, openness, and excellence create trust among stakeholders. However, the construction industry still requires a contract because of the challenges of upholding the dedication and openness of a project (Gavali & Halder 2020). Further, there are several activities during the construction phase, which involve a lot of hard copy documentation and information sharing. Furthermore, securing necessary signatures on physical documents often leads to delays, escalating both the time and cost of the project (Guo et al. 2021). To overcome this, the construction industries have been utilizing information technology (IT) to manage the information and documents in real time for smooth operations on the site. Generally, there are three types of IT applications: project management information system (PIMS), enterprise resource planning (ERP) system, and electronic document management system (EDMS). The differences between the above-mentioned systems are described in Table 1.1, from which EDMS is the most appropriate system for proper document and information management.

EDMS is a software platform that can electronically create, submit, and share documents through a common platform, allowing users to view, download, provide comments, approve, or take other actions in real-time (Guo et al. 2021). Further, it also offers a wide range of features such as version control, document retention policies, search and retrieval, security and access control, and audit trails. It can be customized to meet the specific needs of an organization and can be integrated with other software applications. Figure 1.1 shows some of the important features offered by EDMS in construction projects. Shi & Halpin (2003) stated that EDMS is utilized to obtain resources on schedule and with less overhead by cutting down on the amount of time needed for the procurement of documents.

Table 1.1: Comparison of PIMS, ERP, and EDMS

Feature	**PIMS**	**ERP**	**EDMS**
Objective	To ensure projects are completed on time, within budget, and meet quality standards.	To optimise business processes, increase efficiency, and provide a unified view of the business.	To improve the retrieval sharing, sharing and security of documents while reducing paper use.
Key components	Project scheduling, Resource allocation, Budget management, Risk management, and Communication management.	Finance, Human resources, Manufacturing, Supply chain, Services, and Procurement.	Document capture, Storage, search, retrieval, Workflow, Security, and Archiving.
Data handling	Deals primarily with project-related data such as timelines, milestones, and performance metrics.	Handles a wide range of data across various functions, including financial and operational data.	Focuses on the storage, retrieval, and management of documents in various formats.
Exapmles	Aconex, Procore, etc.	SAP ERP, Oracle ERP Cloud,Sage 300 Construction and Real Estate, etc.	Microsoft SharePoint, DocuWare, Bluebeam Revu, etc.

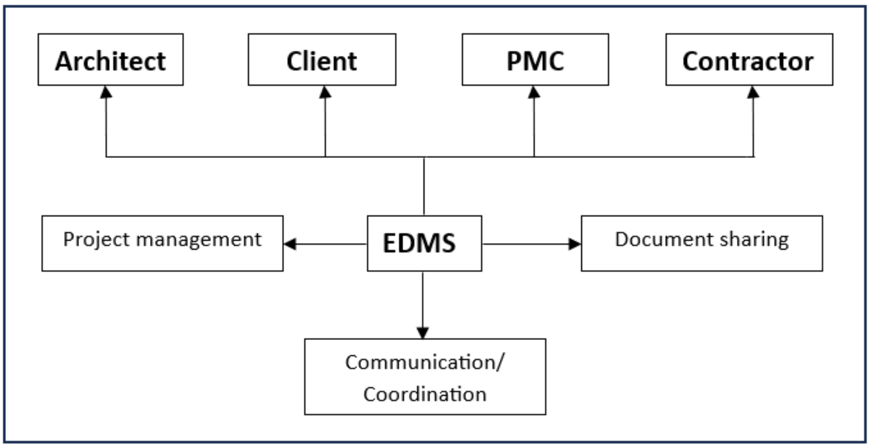

Figure 1.1: Features of EDMS

1.2 Need of study:

Overall, EDMS is familiar to the construction industry, but it is still new to the Indian construction industry. Large-scale construction companies in India use somewhat EDMS in one way or another to manage and handle their documents by developing their system or purchasing it from certain service providers. However, Small and Medium Enterprises(SME) construction companies in India are still struggling to adopt this new system. This study aims to investigate the attributes that might impact the implementation of EDMS in SME construction companies in India.

1.3 Objective of study:

The objectives of the study are:-

- To identify success and barrier factors and develop a hypothetical model for EDMS in SME in the Indian Construction Industry.
- To develop and analyze a path model for the impact of barriers in the implementation of the EDMS.

1.4 Scope of work:

This research focuses on SMEs (Small and medium-sized enterprises) mostly from the western region of India i.e. Gujarat, Rajasthan, and Maharashtra. And will encompass residential, commercial, or combined projects (i.e., residential + commercial projects).

1.5 Outline of the thesis:

Chapter 1 - Introduction: This chapter provides a general introduction to the topic, emphasizing the implementation of EDMS in the SME's Indian Construction Industry. It defines the importance of digitization in construction to achieve modern standards and the main pillars of the construction industry.

Chapter 2 - Literature Review: This section reviews the literature on the success and barriers factors for implementing EDMS in the construction industry, highlighting the importance of organizational readiness, strategic alignment, customization, stakeholder engagement, and technological challenges. It emphasizes the need for an in-depth analysis specific to the Indian construction industry, addressing the gaps in existing research and proposing the development of an EDMS implementation model.

Chapter 3 - Research methodology: This chapter describes the research methods used to meet the study's objectives. It begins with identifying success and obstacle features for EDMS deployment based on significant literature analysis and expert interviews. The approach is divided into many stages, which include the creation of a questionnaire, a pilot survey, an expert survey, data collecting, and analysis. Validating the detected features and their interrelationships is accomplished using techniques such as Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA), and Structural Equation Modelling (SEM). This methodical methodology enables a thorough assessment of the parameters influencing EDMS usage in the Indian construction sector.

Chapter 4 - Results and Discussion This chapter presents and discusses the data collecting and analysis outcomes in depth. The chapter delves into the ranking success and barrier qualities and their respective effects on EDMS deployment. It highlights the results of the exploratory and confirmatory factor analyses, emphasizing important success aspects such as project monitoring, enhanced decision-making procedures, and greater stakeholder coordination. The chapter also discusses the identified impediments, such as technological problems and opposition to change, and provides strategic solutions for overcoming them. The conversation combines theoretical insights with practical ramifications, resulting in a more nuanced understanding of EDMS deployment in SMEs in the Indian construction sector.

Chapter 5 - Summary and Conclution The last chapter summarises the study's important results, emphasizing the relevance of EDMS in improving project performance in the Indian construction industry. It discusses the study's contributions to existing knowledge, including the creation of a context-specific model for EDMS implementation. The chapter also discusses the study's shortcomings and proposes topics for further research, emphasizing the need of continued research into the changing dynamics of EDMS and its larger implications for the construction sector. The conclusion emphasizes the study's significance and the prospective advantages of using EDMS for SMEs in India, opening the path for further advances in this area.

Chapter 2

Literature Review

2.1 Prologue:

The literature review is a crucial aspect of any research work since it discusses previously published information and identifies gaps in past research and practice. The following sections in this chapter summarise a comprehensive review of EDMS usage in the construction industry.

2.2 Summary of literature:

EDMS has garnered research interest in recent years, receiving significant and equal attention from practitioners and researchers. However, the successful implementation of EDMS in the construction industry is significantly influenced by success attributes. Ahmad & Cuenca (2013) emphasize the importance of organizational readiness, including the alignment of EDMS with business processes and the commitment of top management, as key determinants of successful ERP implementations, which can be analogously applied to EDMS in construction. Similarly, Lee & Yu (2011, 2012) identify the integration of project management information systems and the strategic alignment of these systems with project objectives as crucial for achieving project success, underscoring the relevance of strategic planning in EDMS deployment. Gavali & Halder (2020) highlight the criticality of customizing EDMS features to meet the unique requirements of construction projects, pointing to the necessity of flexibility and adaptability in EDMS design.

Additionally, Kukreja & Purohit (2017) underscores the importance of stakeholder engagement and training as essential for facilitating the adoption and effective use of EDMS in the Indian construction context. Despite the recognized benefits, the implementation of EDMS in the construction industry encounters significant barriers. Guo et al. (2021) identified technological challenges, such as the interoperability of EDMS with existing systems and the scalability of solutions to accommodate large-scale projects, as major obstacles. Moreover, Kostikova et al. (2020) discusses the resistance to change among employees, exacerbated by a lack of digital literacy and awareness of EDMS benefits, as a critical barrier to effective implementation. Singh & Singh (2020) and Shrestha & Maharjan (2020) point to the absence of a clear strategy for EDMS implementation and inadequate management support as key organizational barriers. Hjelt & Björk (2006) noted that the complexity of construction projects and the fragmented nature of the industry complicate the adoption process.

2.3 Research gap:

Only a few studies in the literature reported on the success factors of EDMS in construction (Tatari et al. (2008), Chung et al. (2008), Wei et al. (2009), Tatari & Skibniewski (2011), Lee & Yu (2011), Ahmad & Cuenca (2013), Ozorhon & Cinar (2015), Gavali & Halder (2020)). The existing literature predominantly highlighted general barriers and success factors. However, there is a lack of detailed analysis on how these factors play out in the long term, especially in the face of rapidly advancing technology and changing regulatory environments. The nuanced impacts of cultural, organizational, and technological shifts on the effectiveness of EDMS in the construction industry remain unexplored. Therefore, it is essential to identify the success and barrier attributes in implementing EDMS specifically for the construction industry like India. Thus the study needs to be carried out from the perspective of the Indian Construction Industry. Hence this study aims to determine the success and barrier factors for the SEMs in the Indian construction industry and develop the hypothetical model.

2.3.1 Overview of Exploratory Factor Analysis (EFA):

EFA is applied to identify a relatively small number of factor groups to depict correlations between sets of several connected variables(Lee & Yu 2011).

Different factor extraction procedures are needed, especially when dealing with small samples, few variables, or different commonality estimations. The most prevalent approach is principal components analysis (PCA), which identifies linear combinations of variables to extract the most variation and removes that variance to create new combinations. The primary axis approach creates orthogonal components while assessing total variance. PCA is useful when there is little prior knowledge about anticipated cluster relationships and can aid in addressing multicollinearity difficulties (Hair et al. 1998).

Factor analysis requires rotating the axes for more accurate interpretation, which has no effect on the goodness-of-fit but makes the results easier to understand. The three most common rotation algorithms are varimax, equimax, and quartimax. The most efficient strategy is Kaiser's (1958) varimax method, which reduces the number of variables with high loadings on numerous factors, therefore clearly separating factor loadings (Fox & Skitmore 2007).

Several pre-tests examine sample characteristics to guarantee that factor analysis is effective. The Kaiser-Meyer-Olkin (KMO) test of sample adequacy, with values ranging from 0 to 1.0, should be 0.60 or higher for successful factor analysis (Fox & Skitmore 2007). The Bartlett Test of Sphericity uses a chi-square approximation to determine if the sample's correlation matrix is the identity matrix. This is particularly critical for small samples (over 100) having less than ten variables. Furthermore, the anti-image correlation matrix must have a sampling adequacy (MSA) of at least 0.5 to eliminate variables with low MSA (Hair et al., 1998).

The reliability of attributes was evaluated using Cronbach's alpha (Cα). The Cα values range between 0 to 1. As per research, the desirable value of Cα should be 0.7 or above, if it is less than 0.7, it is considered undesirable or lousy reliability.

2.3.2 Overview of Confirmatory Factor Analysis (CFA):

CFA is a fundamental statistical method used to validate the factor structure identified through exploratory methods such as Exploratory Factor Analysis (EFA) (Hair Jr et al. 2014). It is particularly useful in assessing whether the data correspond to a hypothesized measurement model that has both theoretical and empirical support (Hair Jr et al. 2014). CFA explores the relationships between observable variables and their underlying latent constructs, and it builds the model by evaluating the adequacy of each construct's representation. Academics widely use CFA to evaluate components and ensure model accuracy.

The application of CFA involves multiple stages. Initially, a hypothesized model is developed based on existing research findings. Subsequently, data is collected through a structured survey conducted within the construction industry. The goodness-of-fit (GOF) indices are determined by running the model through CFA. This process helps assess the validity of a scale by evaluating the model's GOF. Establishing the instrument's validity requires an acceptable fit, which can be evaluated using various indices such as the goodness of fit index (GFI), comparative fit index (CFI), root mean square error of approximation (RMSEA), normed fit index (NFI), Tucker Lewis index (TLI), and chi-square/df criteria (Alavi et al. 2020, Marsh et al. 2020). This connected process ensures that the model is accurately represented and validated, enhancing the reliability of the instrument and its subsequent inferences.

CFA also assesses both convergent and discriminant validity to verify the concepts' validity and reliability. Convergent validity indicates that items designed to assess the same concept are highly related, while discriminant validity ensures that constructs intended to be distinct are indeed distinct (Fornell & Larcker 1981). By validating these features, CFA enhances the reliability of the model and its inferences.

2.3.3 Overview of Structural Equation Modelling (SEM):

Structural Equation Modeling (SEM) is a confirmatory multivariate method that integrates factor analysis and multiple regression. Its broad range of applications in causal analysis has made SEM a widely accepted method in the social sciences, including fields such as psychology, economics, sociology, political science, marketing, health, and education. Despite its clear benefits, SEM remains underutilized in construction engineering and management studies (Molenaar et al. 2000). This underutilization suggests an opportunity for further exploration and application of SEM in these areas, potentially leading to more robust and comprehensive research outcomes.

According to Chen et al. (2012), SEM comprises two models: a measurement model known as confirmatory factor analysis, and a structural model referred to as regression or path analysis. The structural model describes the causal relationships between latent variables (Molenaar et al. 2000, Wong & Cheung 2005). One of the key benefits of SEM is its ability to model and evaluate correlations between multiple independent and dependent variables simultaneously (Molwus et al. 2013). Unlike other multivariate statistical methods, such as regression analysis, SEM accounts for measurement errors and generates a single model that encompasses the entire set of relationships (Molwus et al. 2013). This integrated approach allows for a more comprehensive analysis of complex data sets, enhancing the reliability and validity of the research findings.

SEM is divided into two types: covariance-based SEM (CB-SEM) and variance-based SEM (VB-SEM). CB-SEM utilizes software to evaluate covariance matrices, confirming the model's theoretical basis and explaining the relationships between observable and latent variables. Conversely, VB-SEM employs the partial least-squares (PLS) technique to determine the relationships between latent variables by expressing the amount of variance explained (S. Davcik 2014). While VB-SEM is similar to multiple regression analysis, CB-SEM verifies theories by assessing a model's ability to predict a covariance matrix for sample data (Hair Jr et al. 2014). The maximum likelihood approach is the most commonly used method for calculating covariance in SEMs (Cho et al. 2009). This connected approach allows researchers to select the appropriate SEM type based on their theoretical and empirical needs, enhancing the robustness and validity of their findings.

Due to its advantages, SEM has been widely used in various areas of construction management. For instance, it has been applied to determine the relationship between trust and partnering success (Wong & Cheung 2005), investigate organizational and collaborative dynamics in the construction project claims process (Aibinu et al. 2011), and define success traits for construction projects (Tabish & Jha 2012). Additionally, SEM has been utilized to explore factors affecting delays in Indian construction projects (Doloi et al. 2012), examine relationships among critical success factors of construction projects (Chen et al. 2012), determining success for construction organization (Tripathi & Jha 2018), and determine safety performance in construction projects (Patel & Jha 2016). The extensive use of SEM in recent research highlights its reliability and practical utility, underscoring its significance in construction management studies.

Chapter 3

Research methodology

3.1 Prologue:

To fulfill the objectives of the study the methodology is formed based on various literature reviews. The procedure of the study is defined into the following six steps shown in Figure 3.1.

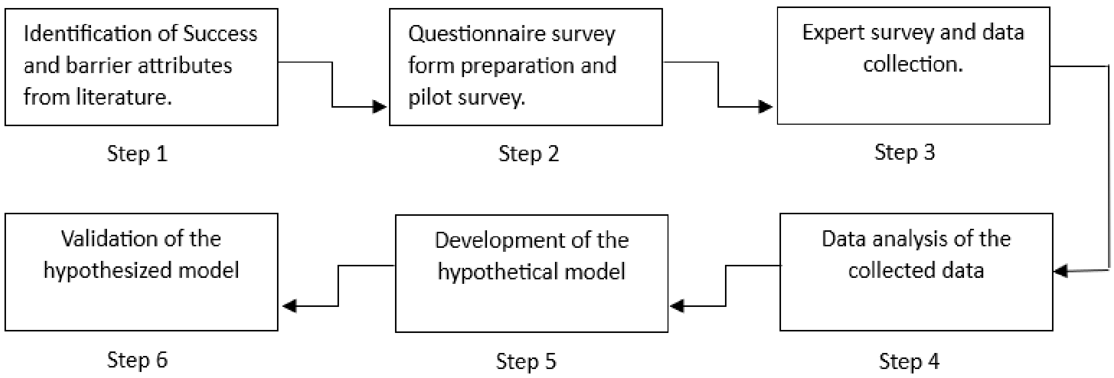

Figure 3.1: Methodology of research

3.2 Identification of success and barrier attributes:

In total, 15 success attributes and 7 barrier attributes were identified from various literature, as shown in Table 3.1 and Table 3.2. A list of these attributes was circulated among five experts with 25-plus years of experience in the Indian construction industry for a detailed study to check whether these attributes are relevant and applicable to the Indian construction industry or not. The experts found the list satisfying for further study.

Table 3.1: Success attributes and sources

ID	Success Attributes	References
SA1	Project Monitoring & Controlling	Gavali & Halder (2020), Ozorhon & Cinar (2015), Ahmad & Cuenca (2013)
SA2	Improves Decision-Making Processes	Ahmad & Cuenca (2013), Gavali & Halder (2020), Ozorhon & Cinar (2015)
SA3	Proper Flow of Information in Organization	Trivedi et al. (2022), Churacharit & Chutima (2022), Ozorhon & Cinar (2015), Gavali & Halder (2020)
SA4	Better Coordination Among Stakeholders	Churacharit & Chutima (2022), Trivedi et al. (2022), Gavali & Halder (2020), Lee & Yu (2012), Ozorhon & Cinar (2015)
SA5	Clear Channel of Communication	Trivedi et al. (2022), Lee & Yu (2012), Gavali & Halder (2020), Ozorhon & Cinar (2015), Churacharit & Chutima (2022)
SA6	User Interface of System (Easy to Use)	Singh & Singh (2020), Gavali & Halder (2020), Ozorhon & Cinar (2015), Ahmad & Cuenca (2013), Lee & Yu (2011)
SA7	Quality Output of Information from the System	Churacharit & Chutima (2022), Gavali & Halder (2020), Ozorhon & Cinar (2015), Lee & Yu (2011)
SA8	Framework of EDMS (Software Configuration)	Gavali & Halder (2020), Ozorhon & Cinar (2015), Ahmad & Cuenca (2013), Lee & Yu (2011)
SA9	Improves Security of the Documentation	Lee & Yu (2012), Trivedi et al. (2022), Churacharit & Chutima (2022), Gavali & Halder (2020), Lee & Yu (2011)
SA10	Fast and Accurate Data Reentry	Trivedi et al. (2022), Lee & Yu (2012), Gavali & Halder (2020)
SA11	Software Customization	Singh & Singh (2020), Gavali & Halder (2020), Lee & Yu (2011, 2012)

Continued on next page

Table 3.1 continued from previous page

ID	Success Attributes	References
SA12	Accessibility (Remotely Accessible from Anywhere)	Lee & Yu (2011), Gavali & Halder (2020), Ozorhon & Cinar (2015)
SA13	Reliability of EDMS	Gavali & Halder (2020), Lee & Yu (2011, 2012)
SA14	Vendor & Consultant Support	Gavali & Halder (2020), Lee & Yu (2012), Ozorhon & Cinar (2015)
SA15	Quick Data Analysis and Conversions	Ahmad & Cuenca (2013), Gavali & Halder (2020), Lee & Yu (2011)

Table 3.2: Barrier attributes and sources

ID	Barrier Attributes	References
BA1	Substantial Initial Investment	Ahmad & Cuenca (2013), Shrestha & Maharjan (2020), Gavali & Halder (2020), Kukreja & Purohit (2017)
BA2	Lack of Awareness	Shrestha & Maharjan (2020), Ahmad & Cuenca (2013)
BA3	Training/User Lack Proper Training to Use EDMS	Kukreja & Purohit (2017), Shrestha & Maharjan (2020), Gavali & Halder (2020)
BA4	Resistance to Change	Shrestha & Maharjan (2020), Gavali & Halder (2020)
BA5	Lack of Standardization	Shrestha & Maharjan (2020), Al Qady & Kandil (2013), Kukreja & Purohit (2017), Gavali & Halder (2020)
BA6	Adequate Software Selection	Gavali & Halder (2020), Ahmad & Cuenca (2013)
BA7	Lack of Skilled User	Churacharit & Chutima (2022), Shrestha & Maharjan (2020), Gavali & Halder (2020)

3.2.1 Success attributes for EDMS:

SA1- Project monitoring and controlling:- The success attribute ”Project Monitoring and Controlling” for EDMS ensures the effective management of project progress, resource allocation, and cost control in real-time. This capability facilitates prompt decision-making and proactive risk mitigation.

SA2- Improves Decision-Making Processes:- The success attribute "Improves Decision-Making Processes" enhances project stakeholders' access to real-time information, enabling them to make timely and informed decisions. This capability ultimately improves project outcomes and efficiency.

SA3- Proper Flow of Information in Organization:- The success attribute "Proper Flow of Information in Organization" ensures the seamless distribution and retrieval of project-related data among stakeholders, thereby promoting collaboration, transparency, and efficiency.

SA4- Better Coordination Among Stakeholders:- The success attribute "Better Coordination Among Stakeholders" for EDMS fosters coordinated communication and collaboration among project participants. This enhancement optimizes workflows, reduces conflicts, and increases overall project efficiency.

SA5- Clear Channel of Communication:- The "Clear Channel of Communication" attribute of EDMS enables easy and transparent information exchange between project stakeholders, reducing miscommunication and delays. It facilitates the sharing of documents, updates, and feedback on a single platform, enhancing teamwork and decision-making. This transparency fosters a cohesive work environment, allowing teams to swiftly overcome obstacles and maintain project momentum.

SA6- User Interface of System (Easy to Use):- The success attribute "User Interface of System" for EDMS refers to a clear and user-friendly interface that simplifies navigation and retrieval of project documentation. A well-designed interface facilitates effective document management and collaboration among project teams, thereby increasing user adoption and productivity.

SA7- Quality Output of Information from the System:- The success attribute "Quality Output of Information from the System" for an EDMS in the Indian construction industry ensures the delivery of accurate, timely, and comprehensive information. This capability enhances decision-making, streamlines project management, and improves overall efficiency in construction projects.

SA8- Framework of EDMS (Software Configuration):- The success attribute "Framework of EDMS (Software Configuration)" for the Indian construction industry emphasizes the system's adaptability, scalability, and integration capabilities. A wellconfigured EDMS supports diverse project requirements, seamlessly integrates with existing tools, and scales with project size, ensuring consistent performance and user satisfaction.

SA9- Improves Security of the Documentation:- The success attribute "Improves Security of the Documentation" for an EDMS in the Indian construction industry ensures the protection of sensitive project data through robust access controls, encryption, and audit trails. This reduces the risk of data breaches and unauthorized access, thereby safeguarding critical project information.

SA10- Fast and Accurate Data Re-entry:- The success attribute "Fast and Accurate Data Re-entry" for an EDMS in the Indian construction industry minimizes manual entry errors and accelerates data input processes. This ensures that project information is promptly and accurately updated, enhancing operational efficiency and data reliability.

SA11- Software Customization:- The success attribute "Software Customization" for an EDMS in the Indian construction industry allows the system to be tailored to specific project needs and workflows. This flexibility enhances user adoption and optimizes project management processes.

SA12- Accessibility (Remotely Accessible from Anywhere):- The success attribute "Accessibility (Remotely Accessible from Anywhere)" for an EDMS in the Indian construction industry enables project stakeholders to access documents and data from any location. This facilitates real-time collaboration, quick decision-making, and operational continuity, which is especially crucial for geographically dispersed teams.

SA13- Reliability of EDMS:- The success attribute "Reliability of EDMS" for the Indian construction industry ensures consistent system performance with minimal downtime and robust data integrity. This reliability builds user trust, ensuring seamless project management, reducing delays, and enhancing productivity.

SA14- Vendor and Consultant Support:- The success attribute "Vendor and Consultant Support" for the EDMS in the Indian construction industry ensures ongoing assistance and expertise from software providers and consultants. This support is critical for smooth implementation, troubleshooting, and system updates, enabling users to maximize the EDMS capabilities and maintain efficient project operations.

SA15- Quick Data Analysis and Conversions:- The success attribute "Quick Data Analysis and Conversions" for the EDMS in the Indian construction industry enables rapid processing and transformation of project data into actionable insights. This capability supports timely decision-making, enhances project planning, and improves overall efficiency by allowing stakeholders to swiftly interpret and utilize complex data sets.

3.2.2 Barrier attributes for EDMS:

BA1- Substantial Initial Investment:- The barrier attribute "Substantial Initial Investment" for the EDMS in the Indian construction industry refers to the high upfront costs associated with purchasing, implementing, and customizing the system. These expenses can be a significant deterrent for many firms, particularly smaller ones, affecting their willingness or ability to adopt the technology.

BA2- Lack of Awareness:- The barrier attribute "Lack of Awareness" for the EDMS in the Indian construction industry pertains to limited understanding or knowledge about the benefits and functionalities of EDMS. This lack of awareness can hinder adoption, as stakeholders may not recognize the potential advantages. Consequently, there may be reluctance or resistance to implementing the technology, despite its potential to improve efficiency and streamline operations.

BA3- Training/User Lack Proper Training to Use EDMS:- The barrier attribute "Training/User Lack Proper Training to Use EDMS" indicates a deficiency in providing adequate training and support to users on effectively utilizing the EDMS. This limitation can result in underutilization of the system's features, inefficiencies in document management processes, and potential frustration among users, thereby hindering the system's successful implementation and adoption.

BA4- Resistance to Change:- The barrier attribute "Resistance to Change" for the EDMS in the Indian construction industry refers to stakeholders' reluctance to embrace new technologies and methodologies for document management. This resistance may stem from ingrained workflows, fear of disruption, or lack of confidence in the new system's benefits. Overcoming this barrier requires effective change management strategies, clear communication of the system's advantages, and addressing concerns to encourage buy-in and ensure successful implementation.

BA5- Lack of Standardization:- The barrier attribute "Lack of Standardization" for the EDMS in the Indian construction industry refers to the absence of uniformity in document management practices and formats across projects and organizations. This inconsistency can lead to interoperability issues, difficulties in sharing information, and increased complexity in managing documents efficiently. Overcoming this barrier requires establishing industry-wide standards, protocols, and guidelines for document management to ensure seamless collaboration and integration of EDMS across the sector.

BA6- Adequate Software Selection:- The barrier attribute "Adequate Software Selection" for the EDMS in the Indian construction industry denotes the challenges in identifying and selecting the most suitable electronic document management system for specific project requirements. This barrier can result from a lack of understanding of available options, leading to potential mismatches between the chosen software and project needs, thereby hindering efficient document management processes.

BA7- Lack of Skilled User:- The barrier attribute "Lack of Skilled Users" for the EDMS in the Indian construction industry highlights a shortage of individuals with the necessary expertise to effectively operate and utilize the system. This limitation can impede the system's implementation and prevent it from fully streamlining document management processes and improving project efficiency.

3.3 Development of questionnaire and pilot survey:

Based on the identified attributes, a questionnaire form was created for the pilot survey, consisting of three parts: Part 1 included all the attributes, Part 2 provided space for comments by the experts, and Part 3 collected details about the individual and their organization. Five industrial experts with more than 25 years of experience were selected for the pilot survey Dikmen et al. (2005). Following their valuable feedback, comments, and inputs, the final questionnaire survey form was prepared.

In the final forms, two types of questionnaire forms were developed: one for in-person interviews and one for online surveys. For personal interviews, a hard copy form with five parts was created, as shown in Figures 3.2,3.3 and 3.4. The first part included an evaluation of success attributes by respondents using a five-point Likert scale: 1 = Not significant, 2 = Less significant, 3 = Fairly significant, 4 = Significant, and 5 = Extremely significant. A five-point Likert scale was recommended over a seven-point Likert scale because it improves response rate and quality while reducing respondents' annoyance Buttle (1996). Additionally, the interviewer can easily read out the entire rating list Dawes (2008). The second part included respondent reviews of the barrier attributes on the same five-point Likert scale. The third part provided space for respondents to offer their valuable input and comments. Parts four and five collected details about the respondents and their organizations. For the online survey, a Google Form was created to replicate the format of the personal interview form.

Institute of Technology, Nirma University

Department of Civil Engineering

Determining sucess factors and barriers for EDMS(Electonic Document Management System) in Indian construction industry.

Takshal Jagdishbhai Prajapati

M. Tech Construction Technology and Managenet, Semester -III

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Electronic Document Management System (EDMS) is a software platform that manages, stores, and tracks electronic documents and images of paper-based information. It provides a centralized repository for storing, managing, and sharing documents, facilitating better collaboration and productivity.

Questionnaire

Part- 1 Please put a tick mark (✓) on the relevant number to rate the following constrains (on five point Likert scale from not significant = 1 to extremely significant = 5) which affect the sucess of EDMS(Electronic Document Management System) in Indian construction industry.

Sr. No.	Success Attributes	Not Significant	Less Significant	Fairly Significant	Significant	Extremely Significant
		1	2	3	4	5
1	Project monitering & controling					
2	Improves decision-making processes					
3	Proper flow of information in organization					
4	Better coordination amongs stakeholder					
5	Clear chanel of communication					
6	User interface of system (easy to use)					
7	Quality output of information from system					
8	Framework of EDMS (Software configuration)					
9	Improves security of the documentation					
10	Fast and accurate data re-entry					
11	Software customization					
12	Accessiblity (Remotely accessible from anywhere)					
13	Reliability of EDMS					
14	Vendor & consultant support					
15	Quick data analysis and conversions					

Figure 3.2: Survey form FS part 1

Part- 2	Please put a tick mark (✓) on the relevant number to rate the following constrains (on five point Likert scale from not significant = 1 to extremely significant = 5) which affect the barriers of EDMS(Electronic Document Management System) in Indian construction industry.					
Sr. No.	Barrier Attributes	Not Significant	Less Significant	Fairly Significant	Significant	Extremely Significant
		1	2	3	4	5
1	Substantial initial investment					
2	Lack of awareness					
3	Training/user lack proper training to use EDMS					
4	Resistance to change					
5	Lack of standardization					
6	Adequate software selection					
7	Lack of skilled user					
Part - 3	Please provide a feedback regarding the factors and their latent factors which have been mentioned here. And also suggest if there is any need to remove any factors/latent factors or to add any. Also you can provide the review from your view point related to the work carried out. Your feedback is extremely valuable for this research work.					

Figure 3.3: Survey form FS part 2

Part - 4	Respondents Information	
1	Name	
2	Contact No.	
3	Email id	
4	Designation	
5	Experience (in years)	
Part- 5	Organizations Information	
1	Name	
2	Type of organization	
3	Experience (in years)	
Note:- This data will be used for academic purpose only and we will not be revealing any details of the respondents and organization .		
Date: _________________		
Place: _________________		
		Thanks for your Participation

Figure 3.4: Survey form BS

3.4 Expert survey and data collection:

After the development of the survey form, a sample was chosen. The sample size is an important issue because it relates to the stability of the parameter estimates Schreiber et al. (2006)). Past study indicates that sample sizes ranging from 100 to 400 are appropriate for analysis (Molwus et al. 2013). The sample size is an important aspect since it decides the stability of parameter estimates (Schreiber et al. 2006). According to Iacobucci (2009), a minimum sample size of 50 and a maximum sample size of 100 can be suitable. The sample size should be at least 3-5 times the number of features (100) Fachrizal et al. (2020). As a consequence, a sample size of 107 for the survey was considered appropriate.

3.4.1 Data collection:

In total, 107 responses were collected for the study. This research specifically targeted clients, contractors, and project management consultants (PMCs), who are considered the primary users of EDMS within the construction industry, as shown in Figure 3.5 there were 34 respondents from clients, 56 respondents from contractors, and 17 respondents from PMCs. Out of 107 experts, forty-seven percent had 5-10 years of experience, forty percent had 10-20 years, nine percent had 20-30 years, and four percent had more than 30 years of experience as shown in Figure 3.6. Further, respondents were from various project types, including residential, commercial, and mixed-use developments, Figure 3.7 shows the number of the types of projects from where the data was collected i.e. 57 residential projects, 23 commercial, and 30 mixed projects. Further, they work as project managers, senior engineers, junior engineers, and company directors as shown in Figure 3.8.

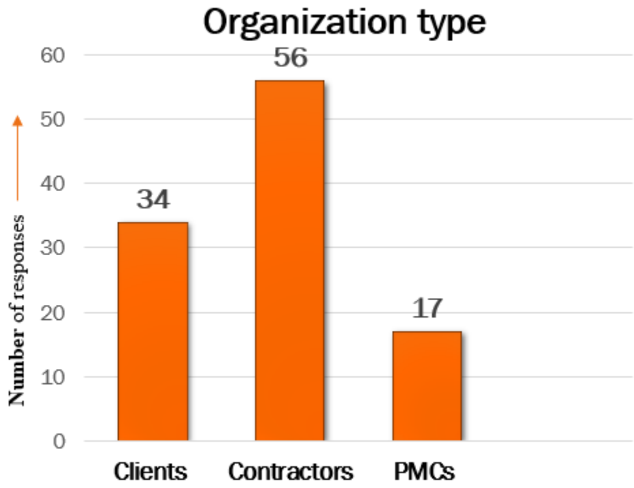

Figure 3.5: Type of Organization

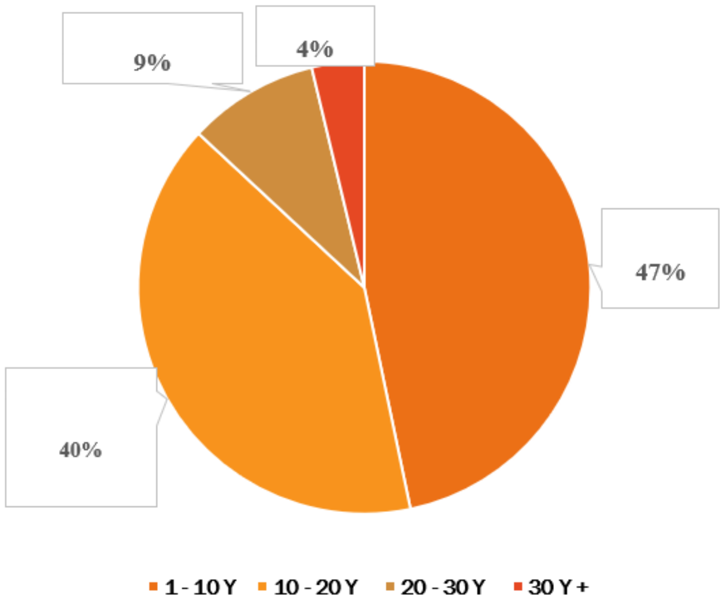

Figure 3.6: Experience of Experts in Years

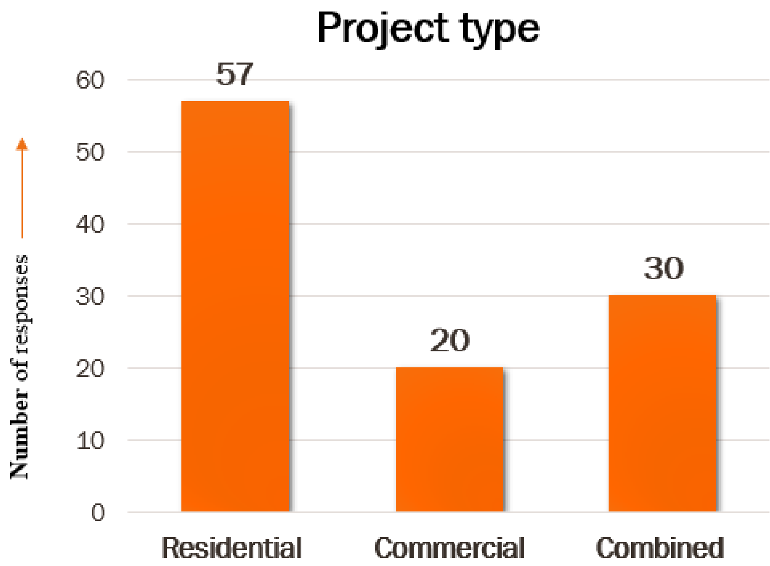

Figure 3.7: Type of Projects

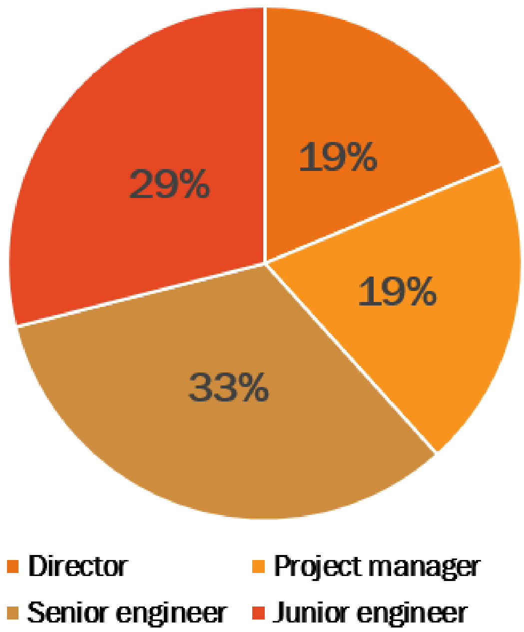

Figure 3.8: Designation of Experts

3.5 Data analysis:

For ranking of the attributes, identified success and barrier attributes were ranked according to their mean values and standard deviations. If two or more attributes had the same mean value, then the attributes with the lower standard deviation were ranked higher. Table 4.1 presents the rankings of success and barrier attributes, respectively, detailed alongside their mean values and standard deviations (SD).EFA will be used as a statistical method in this study's fourth phase to determine the EDMS's success and barrier factors. The data will be analyzed using the SPSS version 23. This study employed this technique to determine the factor groups for the 22 attributes (i.e., 15 success and 7 barrier attributes) (Lee & Yu 2011). Out of these 15 success attributes 4 success factors were extracted and out of the 7 barrier attributes 2 barrier factors were extracted. After the extraction of the factors CFA was performed and hypothesized models for both success factors and barrier factors were developed and checked as per the Gof criteria and reliability tests and path analysis, both the models passed the Gof criteria and reliability test but in the path analysis one factor was eliminated from the success model and the revised model was prepared and all the tests were performed again. The revised model was found perfect fit with strong reliability and high significance. Using the factor analysis SEM was performed the hypothesized model was developed and checked as per the available criteria for the model fit (Gof). reliability test and path analysis were performed on the model. The model was found perfect fit with strong reliability and high significance. The developed model was found deemed suitable for interpretation.

3.6 Hypothesized model development:

After identifying the attributes, a hypothesized model was developed to investigate the relationship between barriers and success factors for the implementation of EDMS in the Indian construction industry. This model is typically illustrated using a path diagram, which depicts relationships with arrows, observed variables with rectangles, and latent constructs with circles. The initial model outlines the relationships between the various constructs and identifies which variables are predicted to influence each construct.

To examine the proposed model, SPSS AMOS 23 was used for Covariance-Based Structural Equation Modeling (CB-SEM). Compared to Variance-Based SEM (VB-SEM), CB-SEM, which relies on covariance matrices, offers significant statistical advantages (Hair Jr et al. 2014). In this study, the maximum likelihood estimation method was employed to analyze the data, allowing for a more robust statistical analysis and providing deeper insights into the relationships between the barriers and success factors for EDMS. The hypothesized model was prepared using IBM SPSS AMOS V23, facilitating a comprehensive evaluation of the proposed relationships.

The tests such as the null hypothesis (Ho) which says that there's not a significant difference between zero and the path coefficient between barriers and success factors and the alternate hypothesis (Ha) which says that barriers have a significant impact on the success factors for the EDMS.

3.7 Hypothesized model validation:

The relevance of the SEM model is assessed using the findings from covariance structural analysis, as indicated by various GOF indices. If the model is found to be inappropriate, it must be revised. The SEM literature provides several criteria for evaluating the GOF of a particular model, with multiple indices measuring the model's fit from different perspectives. For this study, multiple GOF measures commonly used in both SEM and Confirmatory Factor Analysis (CFA) were employed to confirm the hypothesized relationship between the barriers and success factors for EDMS (Patel & Jha 2016, Tripathi & Jha 2018).

The criteria for the evaluation of GOF are

- **Ratio of chi-square (χ^2) to the degree of freedom (df)**: This index compares the observed covariance matrix with the covariance matrix estimated by assuming that the tested model is true (Chen et al. 2012). A lower ratio indicates a better fit.

- **Goodness of Fit Index (GFI)**: This absolute fit index measures how well the hypothesized theory fits the data. The GFI ranges from 0 to 1 and is affected by sample size, increasing with larger samples (Molwus et al. 2013).

- **Incremental Fit Index (IFI)**: The IFI compares the chi-square for the tested model to a hypothesized model, indicating the relative improvement in fit compared to a baseline model (Tripathi & Jha 2018).

- **Tucker-Lewis Index (TLI)**: The TLI takes into account model complexity and sample size, providing a measure of fit that adjusts for these factors (Patel & Jha 2016).

- **Comparative Fit Index (CFI)**: The CFI represents the relative improvement in fit of the hypothesized model. It is robust to sample size variations and performs well even with small samples (Chen et al. 2012).

- **Root Mean Square Error of Approximation (RMSEA)**: This index measures the difference between the observed and estimated covariance matrices per unit of degrees of freedom. Lower values of RMSEA indicate a better fit (Tripathi & Jha 2018).

- **Expected Cross-Validation Index (ECVI)**: The ECVI assesses the stability of the model's results, helping to determine if the model's fit is likely to be consistent across different samples (Sinesilassie et al. 2019).

The recommended level of these measures is given in Table 3.3 (Tripathi & Jha 2018, Molenaar et al. 2000, Sinesilassie et al. 2019)

Table 3.3 shows the recommended level of GOF measure, Chi-square/degree of freedom

Table 3.3: GOF Measures

No.	GOF Measure	Recommended Level of GOF Measures
1	Chi-square/degree of freedom (χ^2/df)	1 to 2
2	GFI	0 to 1
3	IFI	0 to 1
4	TLI	0 to 1
5	CFI	0 to 1
6	RMSEA	0.05 to 0.1
7	ECVI	The lower value is a better fit

(χ^2/df) should be between 1 to 2, the values GIF, IFI, TLI, and CFI should be between 0 to 1 where 0 indicates no fit, and 1 indicates a perfect fit. RMSEA values should be greater than 0.05 to 0.1, where 0.05 is very good and 0.1 is the threshold. Whereas for ECVI the lower the value better the fit.

Chapter 4

Results and Discussion

4.1 Results

The project is currently at the expert survey stage. Till now 56 percent of the survey is completed and the remaining 44 percent of the survey will be completed by the end of January 2024. The beginning step of the analysis which is overall ranking is done based on the number of responses collected till now, in total 56 responses have been collected. The overall ranking of the success attributes and denial attributes is conducted using an Excel sheet, for which the sum of all responses was calculated for each attribute, and after that average and standard deviation of each attribute were calculated. After the calculation overall ranking was done based on these three aspects. The ranking of the constraints is shown in Table 4.1 and Table 4.2. The ranking generated here is likely to be changed as the survey is yet to be completed this ranking is only a trial-base on 56 percent of the survey, the final analysis will start after the completion of the survey.

4.2 Ranking

The identified success and barrier attributes were rated using their mean values and standard deviations. If two or more attributes had the same mean value, the attributes with the lowest standard deviation were placed higher. Table 4.1 and Table 4.2 presents the rankings of success and barrier attributes, respectively, detailed alongside their mean values and standard deviations (SD).

Table 4.1: Success Attributes

ID	Success Attributes	SD	Mean	Rank
SA1	Project monitoring & controlling	0.66	4.31	2
SA2	Improves decision-making processes	0.65	4.27	3
SA3	Proper flow of information in an organization	0.66	3.36	15
SA5	A clear channel of communication	0.66	3.38	14
SA6	User interface of system (easy to use)	0.70	3.66	11
SA7	Quality output of information from the system	0.56	3.85	8
SA8	Framework of EDMS (Software configuration)	0.66	3.65	12
SA9	Improves security of the documentation	0.75	3.83	9
SA10	Fast and accurate data re-entry	0.57	3.99	5
SA11	Software customization	0.66	3.71	10
SA12	Accessibility (Remotely accessible from anywhere)	0.61	3.94	7
SA13	Reliability of EDMS	0.57	3.97	6
SA14	Vendor & consultant support	0.73	4.20	4
SA15	Quick data analysis and conversions	0.68	4.33	1

Table 4.2: Barriers Attributes

ID	Barriers Attributes	SD	Mean	Rank
BA1	Substantial initial investment	0.73	3.22	6
BA2	Lack of awareness	0.72	3.31	4
BA3	Training/user lack proper training to use EDMS	0.60	3.37	3
BA4	Resistance to change	0.67	3.28	5
BA5	Lack of standardization	0.58	3.54	1
BA6	Adequate EDMS software selection	0.77	3.19	7
BA7	Lack of skilled user	0.57	3.46	2

Table 4.3: Level of Impact of Success and Barrier

Mean Value (μ)	Level of Impact	Success and Barrier
$\mu \geq 4.5$	Very High	None
$4.5 > \mu \geq 3.5$	High	SA01 - SA15 and BA05
$3.5 > \mu \geq 2.5$	Moderate	BA01 - BA04,BA06 AND BA07
$2.5 > \mu \geq 1.5$	Low	B11, B28, B31
$\mu < 1.5$	Very Low	None

4.3 Exploratory Factor Analysis (EFA)

In this study, EFA was performed on all 15 success and seven barrier attributes. Considering this, the study first checks the data adequacy by applying the Kaiser-Meyer-Olkin (KMO) test. This test measures sampling adequacy on a scale from 0 to 1, with values closer to 1 indicating a more suitable sample for factor analysis (Fox & Skitmore 2007). In this study, the results of KMO tests were 0.717 for success and 0.710 for barrier attributes, which is greater than 0.7. The Bartlett test of Sphericity was applied to verify the sample's suitability for factor analysis where the correlation matrix was not an identity matrix, and the results show that the significance level for both attributes was found to be less than 0.01. This result validates the data's appropriateness for factor analysis, indicating a substantial relationship among the variables. Then, the internal consistency of attributes was evaluated using Cronbach's alpha (Cα). The Cα values range between 0 to 1. As per research, the desirable value of Cα should be 0.7 or above, if it is less than 0.7, it is considered undesirable or lousy reliability. The Cα values of success and barriers attributes in the study were 0.779 and 0.735, respectively, which is greater than 0.7. This indicates that all attributes have great internal consistency (Tripathi & Jha 2018). Finally, this research uses Principal Component Analysis (PCA) to identify underlying factors by summarising correlations among variables. PCA works by extracting linear combinations of original variables that maximize variance, subsequently finding orthogonal components to explain the largest portion of the remaining variance. This iterative process is repeated until the number of components equals that of the original variables (Fox & Skitmore 2007). The varimax rotation technique is then applied to simplify the structure and achieve clearer factor loadings for each variable. The selection of factors is guided by the criterion that eigenvalues should be greater than 1.0, helping to determine the appropriate number of factors to extract for a concise analytical outcome (Hair Jr et al. 2014). Thus, the result obtained for factor analysis was used to develop three-level hierarchical frameworks (THFs), as shown in Figure 4.1 and Figure 4.2 for success and barrier attributes.

Success factors

1) Advantages:-The first success factor, "Advantages" with a common variance of 19.555 %, which includes five attributes are (S03) Quality output of information from the system with a factor loading of 0.793, (S12) Accessibility (Remotely accessible from anywhere) with a factor loading of 0.745, (S13) Reliability of EDMS with a factor loading of 0.669, (S09) Fast and accurate data re-entry with a factor loading of 0.640 and (S10) Improves security of the documentation with a factor loading of 0.632. These attributes are major advantages of implementing EDMS in the Indian construction industry.

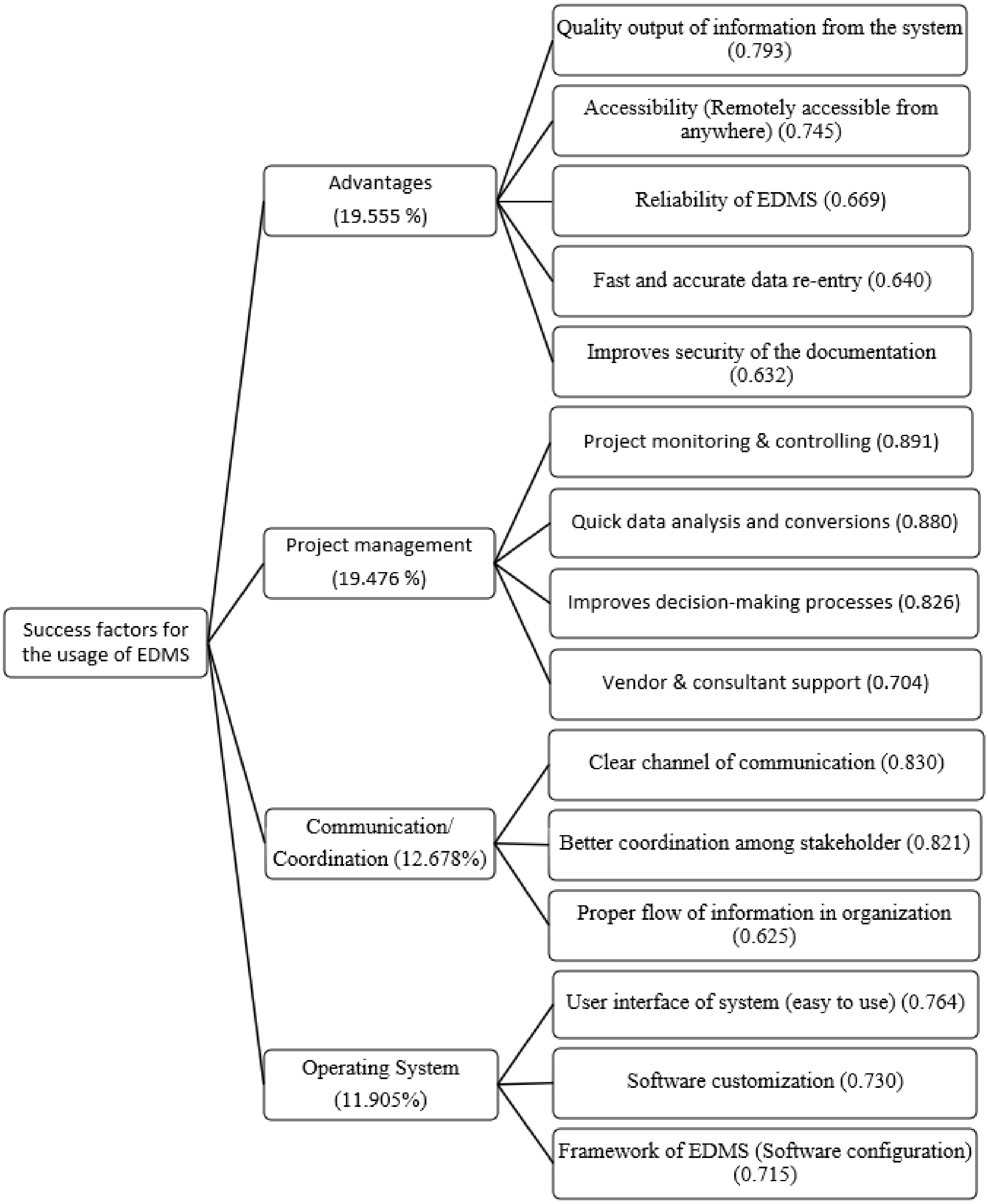

Figure 4.1: Framework of success factors

2) Project management:- The second success factor, "Project management", with a common variance of 19.476 % which includes four attributes (S01) Project monitoring and controlling with a factor loading of 0.891, (S15) Quick data analysis and conversions with a factor loading of 0.880, (S02) Improves decision-making processes with factor loading

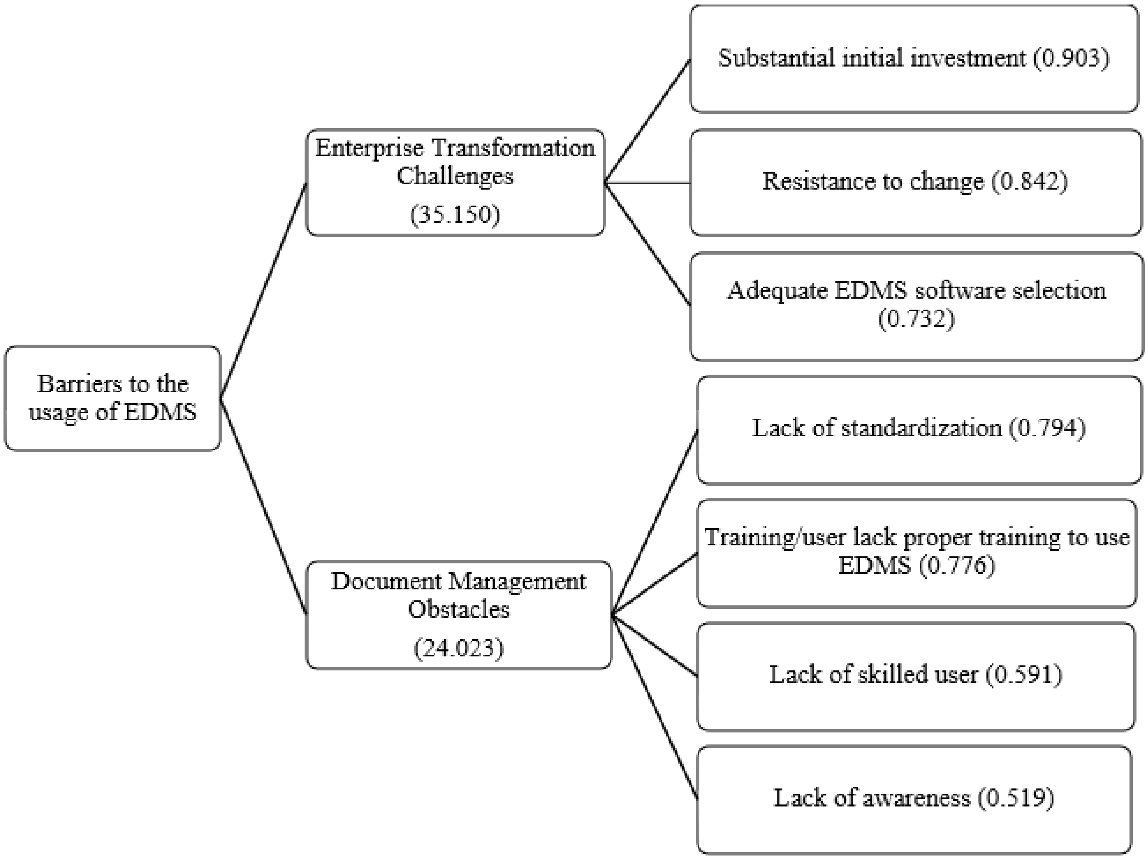

Figure 4.2: Framework of barrier factors

0.826 and (S15) Vendor and consultant support with a factor loading of 0.704. All these attributes have a string factor loading and are related to the management of a project.

3) Communication/Co-ordination:- "Communication/Co-ordination" is the third success factor with a common variance of 12.678 %, which includes three attributes (S05) Clear channel of communication with a factor loading of 0.830, (S04) Better co-ordination among stakeholders with a factor loading of 0.821, and (S03) Proper flow of information in organization with a factor loading of 0.625. These attributes are related to the involvement of communication among all the stakeholders in the project. Thus, it is named "Communication/Co-ordination", and all attributes have strong factor loading.

4) Operating System:- The fourth success factor grouped after the factor analysis was named "Operating system" with a common variance of 11.905 %, including three attributes are (S06) User interface of the system (easy to use) with a factor loading of 0.764, (S11) Software customization with a factor loading of 0.730, and (S08) Framework of EDMS (Software configuration) with a factor loading of 0.715. These are the attributes that strongly indicate the upper hand of a proper EDMS operating system software.

Barrier factors

1) Enterprise Transformation Challenges:- The first barrier factor, "Enterprise Transformation Challenges", has a common variance of 35.150 %, including three attributes which are (B04) Substantial initial investment with a factor loading of 0.903, (B01) Resistance to change with a factor loading of 0.842, and (B06) Adequate EDMS software selection with a factor loading of 0.732. These are the major barriers found at the enterprise level during this study for the implementation and usage of EDMS in the Indian construction industry.

2) Document Management Obstacles:- The second barrier was "Document Management Obstacles", having a common variance of 24.023 %, including four attributes: (B05) Lack of standardization with a factor loading of 0.794, (B03) Lack of proper training to use EDMS with a factor loading of 0.776, (B07) Lack of skilled user with a factor loading of 0.591, and (B02) Lack of awareness with a factor loading of 0.519. Document management is a major issue in the construction industry, as there are several documents and many stakeholders involved in the successful completion of the project. Thus, Document management obstacles are a major barrier to the implementation and usage of EDMS.

4.4 Confirmatory Factor Analysis (CFA)

Using SPSS Amos 23, two hypothesized models for barriers and success factors were developed based on the EFA findings. CFA was carried out utilizing the maximum likelihood estimation technique on these models. Following that, the model's goodness of fit (GoF), construct reliability, and convergent validity were evaluated. These topics will be covered in further detail in the following subsections. Figure 4.3 and 4.4 show the initial CFA models.

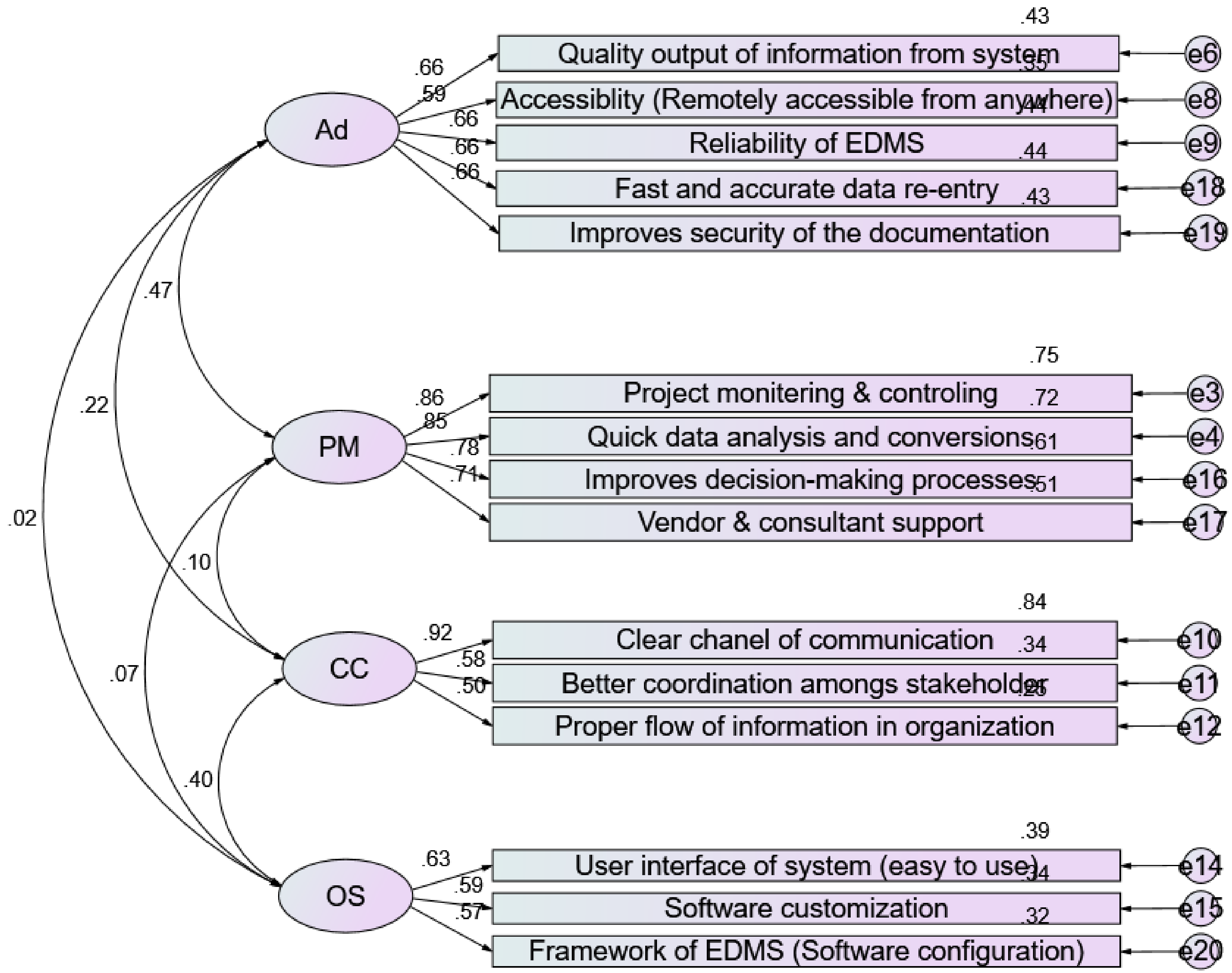

Figure 4.3: Initial CFA model for Success Factor

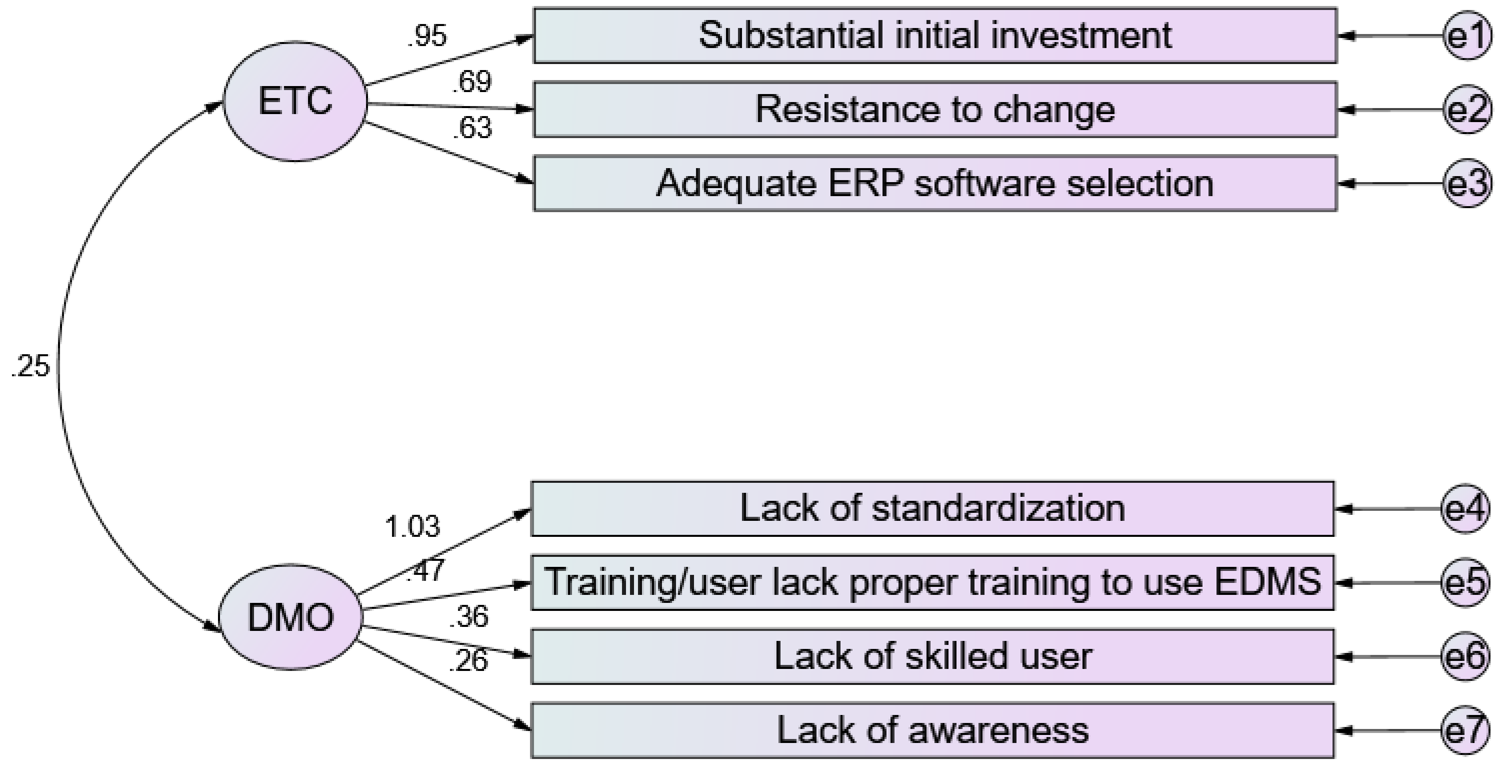

Figure 4.4: Initial CFA model for Barrier factor

4.4.1 Model fit

The levels of recommendation to check the fitness of the model for the CFA is the same as of SEM, represented in Table 3.3. The initial model for the success factors and barriers factors was found to be a perfect fit as it passes through all the recommended criteria. The results of the GOF are shown in Table 4.4 indicating the model and data have a perfect fit. Path analysis was also performed and the results show that all the attributes are significant for the found factors shown in Table 4.5 giving regression weight, standard error (S.E), and critical ratio (C.R) along with their significant levels (P). *** indicates high significance.

Table 4.4: GOF measures for initial model

No.	GOF measure	Success	Barrier
1	Chi-square/degree of freedom (x2 /df)	1.876	2.183
2	GFI	0.829	0.930
3	IFI	0.865	0.916
4	TLI	0.826	0.858
5	CFI	0.86	0.912
6	RMSEA	0.091	0.106
7	ECVI	2.164	0.551

Table 4.5: Path Analysis Results

Path	Estimate	S.E.	C.R.	P	Standardized Estimate
SA01 ← PM	1.095	0.134	8.187	***	0.863
SA15 ← PM	1.109	0.137	8.091	***	0.850
SA07 ← Ad	0.741	0.139	5.330	***	0.657
SA12 ← Ad	0.725	0.147	4.927	***	0.592
SA05 ← CC	1.820	0.464	3.921	***	0.916
SA04 ← CC	1.052	0.246	4.275	***	0.581
SA03 ← CC	1.000				0.505
SA06 ← OS	1.166	0.292	4.000	***	0.628
SA11 ← OS	1.000				0.586
SA02 ← PM	0.975	0.130	7.519	***	0.782
SA14 ← PM	1.000				0.713
SA10 ← Ad	0.770	0.143	5.372	***	0.664
SA09 ← Ad	1.000				0.657
SA08 ← OS	1.000				0.567
SA13 ← Ad	0.768	0.143	5.358	***	0.662

4.4.2 Construct's Reliability and Convergent Validity

Construct reliability assesses the consistency of a variable or group of components with the anticipated outcome (Gefen et al. 2011). On the other hand, Convergent validity is concerned with how closely several measurements of a conceptually linked idea are related (Gefen et al. 2000). Convergent validity is measured using Average Variance Extracted (AVE), while construct reliability is measured using Composite Reliability (CR) and Cronbach's Alpha(Cα). AVE calculates the variance of the latent unobserved variable's indicators to assess its explanatory power. The study assessed construct reliability using Cronbach's Alpha(Cα)and Composite Reliability, in addition to convergent validity by AVE. The SFL values should be above the benchmark of 0.35, and the AVE should be above or around the 0.45 threshold (Fornell and Larcker 1981). Table 4.6 and 4.7 show the results of the factors convergent validity and reliability. The result shows that the majority of success attributes and barrier attributes have SFL values over the benchmark of 0.35 except SA11: Software customization i.e. 0.343 meaning that attribute SA11 was eliminated from the further studies. Additionally to all the success factors and barrier factors have AVE values above the 0.45 threshold except SF4: Operating system which has an AVE value of 0.353 resulting in the elimination of the success factor from further study. After the removal of SF4, the revision of the model was done and analysis was performed again.

Table 4.6: Result of CFA of SUCCESS

Constructs and scale items	SFL
SF1: Advantages (α=0.776 , CR=0.78 , AVE= 0.647)	
SA07: Quality output of information from system	0.432
SA12: Accessibility (Remotely accessible from anywhere)	0.350
SA13: Reliability of EDMS	0.438
SA10: Fast and accurate data re-entry	0.440
SA09: Improves security of the documentation	0.432
SF2: Project management (α=0.875 , CR=0.88 , AVE= 0.419)	
SA01: Project monitoring & controlling	0.745
SA15: Quick data analysis and conversions	0.723
SA02: Improves decision-making processes	0.612
SA14: Vendor & consultant support	0.508
SF3: Communication/Coordination (α=0.708 , CR=0.78 , AVE= 0.556)	
SA05: Clear channel of communication	0.839
SA04: Better coordination among stakeholder	0.463
SA03: Proper flow of information in organization	0.366
SF4: Operating System (α=0.618 , CR=0.62 , AVE= 0.353)	
SA06: User interface of system (easy to use)	0.394
SA11: Software customization	0.343
SA08: Framework of EDMS (Software configuration)	0.321

Table 4.7: Result of CFA of Barriers

Constructs and scale items	SFL
BF1: Enterprise Transformation Challenges (α=0.790, CR=0.81, AVE=0.595)	
BA01: Substantial initial investment	0.908
BA04: Resistance to change	0.477
BA06: Adequate ERP software selection	0.399
BF2: Document Management Obstacles (α=0.750, CR=0.84, AVE=0.576)	
BA05: Lack of standardization	1.067
BA03: Training/user lacks proper training to use EDMS	0.447
BA07: Lack of skilled user	0.434
BA02: Lack of awareness	0.356

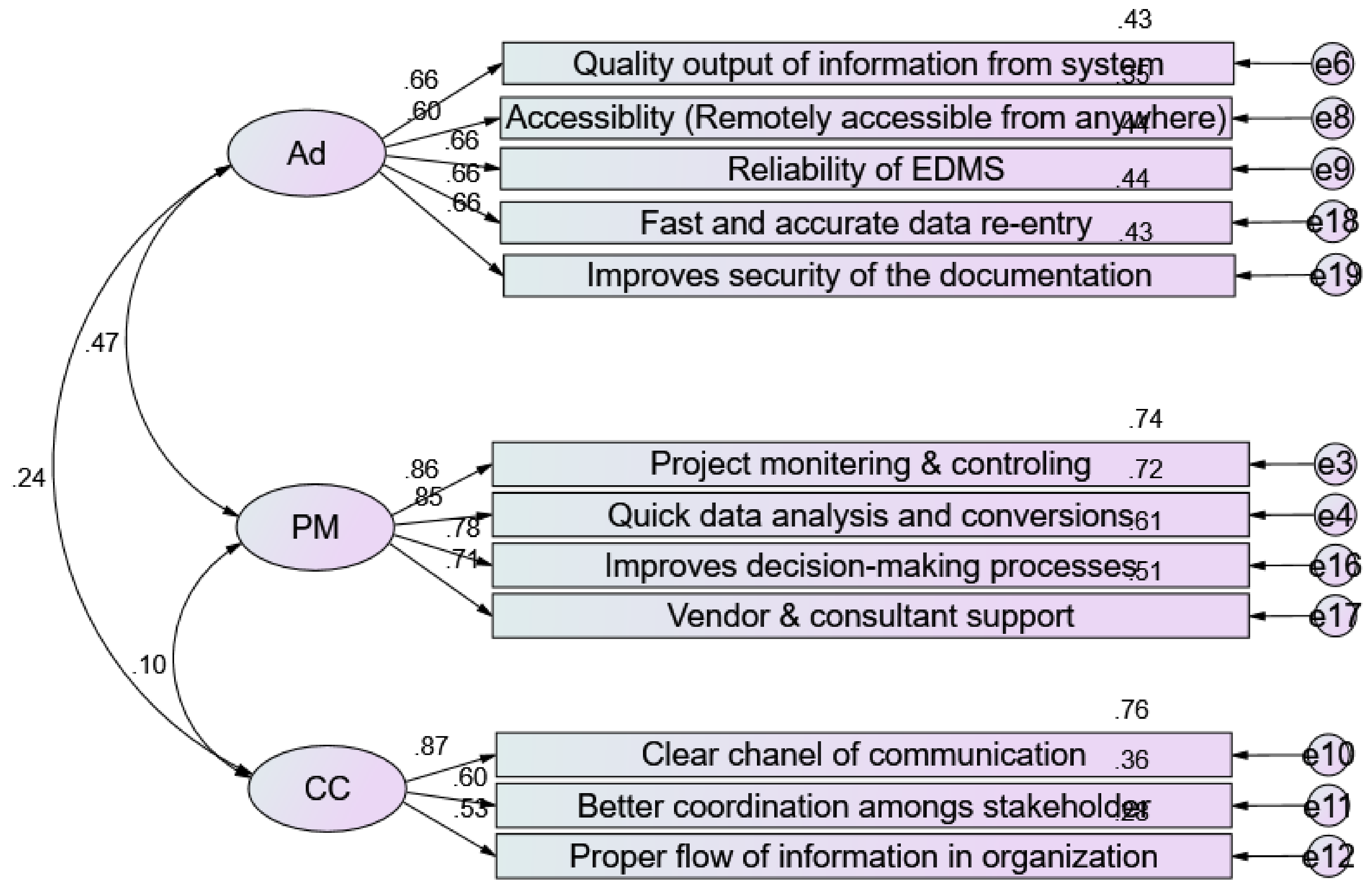

Figure 4.5: Revised CFA model for success factors

4.4.3 Revised model fit

The revised model was prepared based on modifications provided for CFA models.Figure 4.5 shows the revised model for the success factors as per the previous analysis. The revised model for the success factors was found to be a perfect fit as it passes through all the recommended criteria. The results of the GOF is shown in Table 4.8. The GoF results show that every item in this section is well aligned with the hypothesized factors, which is consistent with the findings and suggestions of Hair Jr et al. (2014). The CR values for success were found above 0.6, indicating strong significance since they are higher than the suggested threshold of 0.6 Hair Jr et al. (2014).

Table 4.8: GOF measures for revised model

No.	GOF measure	Success
1	Chi-square/degree of freedom (x2 /df)	2.056
2	GFI	0.850
3	IFI	0.889
4	TLI	0.851
5	CFI	0.885
6	RMSEA	0.100
7	ECVI	1.500

4.4.4 Revised models construct reliability and convergent validity

The construct's reliability and convergent validity were performed on the revised success model the results are shown in Table 4.9. The SFL of all the success attributes was above the benchmark of 0.35 and the AVE valve of all three success factors was above the 0.45 threshold. The CR ranges between 0.78 to 0.89 and the Cronbach's alpha (α) of all the factors are above 0.7 indicating strong significance and high reliability.

Table 4.9: Result of CFA of revised SUCCESS model

Constructs and scale items	SFL
SF1: Advantages (α=0.776, CR=0.78, AVE=0.647)	
SA07: Quality output of information from system	0.433
SA12: Accessibility (Remotely accessible from anywhere)	0.354
SA13: Reliability of EDMS	0.436
SA10: Fast and accurate data re-entry	0.439
SA09: Improves security of the documentation	0.430
SF2: Project management (α=0.875, CR=0.89, AVE=0.469)	
SA01: Project monitoring & controlling	0.743
SA15: Quick data analysis and conversions	0.724
SA02: Improves decision-making processes	0.612
SA14: Vendor & consultant support	0.508
SF3: Communication/Coordination (α=0.708, CR=0.77, AVE=0.538)	
SA05: Clear channel of communication	0.839
SA04: Better coordination among stakeholder	0.463
SA03: Proper flow of information in organization	0.366

4.5 Structural Equation Modelling (SEM)

After combining the attributes, a model was created to study the link between success and performance elements in the construction business, as shown in Figure 5.1. The suggested model was analyzed with AMOS V23, which supports CB-SEM. The maximum likelihood estimation technique was applied in this study (Tripathi & Jha 2018). In the proposed model, ellipses represent the dependent variables, or latent variables or factors; circles indicate measurement errors; and rectangles represent the independent variables, or observable variables or characteristics. The arrows show the direction of the influence. The directing arrow from "CW" to "SA-16" indicates that the success characteristic "SA-16" impacts the success element "CW."Path coefficients are denoted by the numbers above the arrows heading to the latent variables, while factor loadings are represented by the numbers above the arrows flowing from latent variables to observable variables. Based on the research model, the hypothesis asserting that success factors exert a significant positive impact on the performance of the construction industry was evaluated using the following hypotheses:

Null Hypothesis (H0): The path coefficient linking success factors to the success of the construction industry is not significantly different from zero.
Alternative Hypothesis (Ha): Success factors significantly and positively influence the performance of the construction industry.

4.5.1 Results of SEM

The Hypothesized model was developed based on the components found from the factor analysis as shown in Figure4.6 using AMOS V23 software.
The values obtained X2/df = 1.861, GFI = 0.788, IFI = 0.828, TLI = 0.793, CFI = 0.822, RMSEA = 0.090, and ECVI = 3.392 suggest that the hypothesized model was entirely adequate for explaining the interrelationships between success and barrier factors. Consequently, the model was, this model is deemed suitable for interpretation. Table 4.10 and 4.11 shown the results of the SEM model.

Table 4.10: GOF measures for revised model

No.	GOF measure	SEM
1	Chi-square/degree of freedom (x2 /df)	1.861
2	GFI	0.788
3	IFI	0.828
4	TLI	0.793
5	CFI	0.822
6	RMSEA	0.090
7	ECVI	3.392

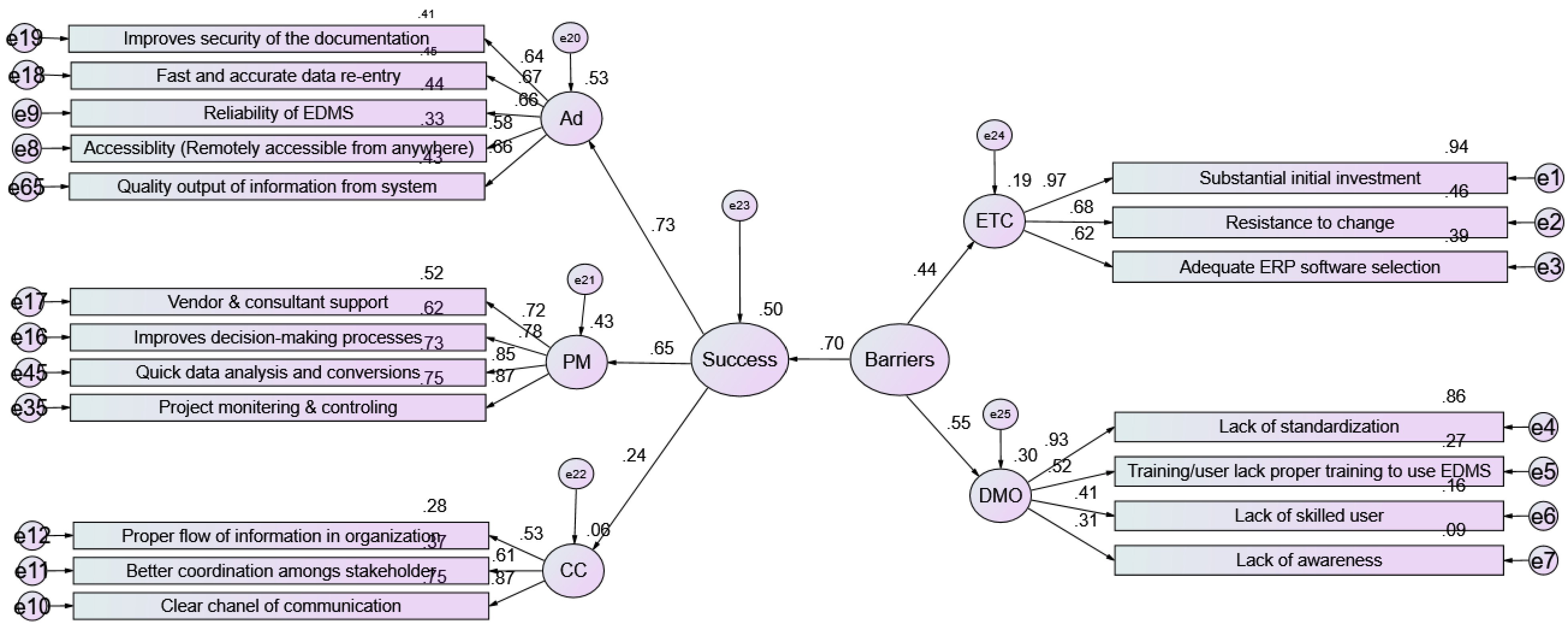

Figure 4.6: SEM model

Table 4.11: Path Analysis Results of SEM model

Path	Estimate	S.E.	C.R.	P	Standardized Estimate
Success ← Barriers	1.141	0.608	1.875	0.061	0.704
Ad ← Success	1.000				0.730
PM ← Success	1.000				0.652
CC ← Success	0.239	0.152	1.568	0.117	0.237
ETC ← Barriers	1.000				0.438
DMO ← Barriers	0.566	0.360	1.573	0.116	0.550
SA01 ← PM	1.084	0.127	8.536	***	0.866
SA15 ← PM	1.099	0.130	8.435	***	0.853
SA07 ← Ad	0.767	0.142	5.400	***	0.658
SA12 ← Ad	0.729	0.150	4.859	***	0.575
SA05 ← CC	1.636	0.429	3.813	***	0.868
SA04 ← CC	1.042	0.240	4.340	***	0.606
SA03 ← CC	1.000				0.532
SA02 ← PM	0.964	0.124	7.785	***	0.785
SA14 ← PM	1.000				0.719
SA10 ← Ad	0.801	0.147	5.466	***	0.669
SA09 ← Ad	1.000				0.641
SA13 ← Ad	0.797	0.146	5.439	***	0.664
BA01 ← ETC	1.443	0.250	5.771	***	0.968
BA04 ← ETC	0.934	0.155	6.039	***	0.681
BA06 ← ETC	1.000				0.624
BA05 ← DMO	2.434	0.937	2.598	0.009	0.926
BA03 ← DMO	1.412	0.518	2.724	0.006	0.521
BA07 ← DMO	1.048	0.420	2.495	0.013	0.405
BA02 ← DMO	1.000				0.306

The created model provides a complete examination of the links between multiple factors influencing the success and barriers in implementing an Electronic Document Management System (EDMS) in the Indian construction industry. The model contains latent variables that indicate success and barrier qualities, which are assessed by observable data. **Sucess factors:** 1) Advantages (Ad):- The factor loadings (path coefficients) between the observed attributes SA07: Quality output of information from the system SA12: Accessibility (Remotely accessible from anywhere), SA13: Reliability of EDMS, SA10: Fast and accurate data re-entry, SA09: Improves security of the documentation and the latent success factor "Ad" are 0.64, 0.67, 0.58, 0.66, and 0.53, respectively. These loadings indicate the strength of the relationship between each observed variable and the latent factor "Ad". For example, "SA09:Improves security of the documentation"has a loading of 0.64 on "Ad", suggesting a moderate to strong relationship.

2)Project Management (PM):- The factor loadings for the observed attributes SA01: Project monitoring & controlling, SA15: Quick data analysis and conversions, SA02: Improves decision-making processes SA14: Vendor & consultant support on latent factor "PM" are 0.52, 0.72, 0.85, and 0.87, respectively. These high loadings indicate strong relationships, particularly with "SA15:Quick data analysis and conversions" and "SA01:Project monitoring controlling". 3) Communication/Coordination (CC):- The loadings for the observed attributes SA05: Clear channel of communication, SA04: Better coordination among stakeholders, and SA03: Proper flow of information in the organization on "CC" are 0.53, 0.61, and 0.66, respectively, indicating moderate to strong relationships. "SA05:Clear channel of communication" has the strongest loading at 0.66. **Barrier factors:** 1)External Transformation Challenges(ETC):- The loadings for the observed attributes BA01: Substantial initial investment, BA04: Resistance to change, and BA06: Adequate ERP software selection on "ETC" are 0.94, 0.68, and 0.62, respectively. "BA01:Substantial initial investment" has an exceptionally high loading, indicating it is a significant barrier. 2)Data Management Obstacles(DMO):- The loadings for the observed attributes BA05: Lack of standardization, BA03: Training/user lacks proper training to use EDMS, BA07: Lack of skilled user, and BA02: Lack of awareness on "DMO" are 0.86, 0.93, 0.52, and 0.31, respectively. "Training/user lack proper training to use EDMS" (e5) has the highest loading, indicating a significant barrier in this category. **Relationships Between Latent Variables:** The relationships between the latent variables in the SEM model highlight the significant factors influencing the success and barriers of EDMS implementation. Advantages (Ad) has a path coefficient of 0.53, indicating that it significantly contributes to the success of EDMS implementation. This suggests that the ability to adapt the system to specific needs and conditions is crucial for the successful integration and use of EDMS. Project Management (PM) also shows a strong positive impact on success, with a path coefficient of 0.43. This underscores the importance of effective project management practices, such as vendor and consultant support, decision-making processes, and project monitoring and control, in ensuring the successful implementation of EDMS. Communication/ Coordination (CC) has a weaker, yet still positive, relationship with success, evidenced by a path coefficient of 0.06. This indicates that while proper information flow, stakeholder coordination, and clear communication channels contribute to success, their impact is less pronounced compared to adaptability and project management. On the side of the barrier, External Transformation Challenges (ETC) have a path coefficient of 0.70, signifying a strong influence on barriers to EDMS implementation. This highlights the substantial impact of external factors like initial investment costs, resistance to change, and ERP software selection on hindering the adoption of EDMS. Data Management Obstacles (DMO) also significantly impact barriers, with a path coefficient of 0.44. This indicates that challenges related to standardization, user training, skill levels, and awareness are critical obstacles that need to be addressed to facilitate successful EDMS implementation. Overall, these relationships emphasize the multifaceted nature of EDMS adoption, where both adaptability and project management are key to success, while external technological challenges and data management obstacles present significant barriers. **Overall relationships:** Barriers → Success: The path coefficient is 0.788, indicating that barrier factors are associated with success, demonstrating a significant relationship between success and barriers. The model includes error terms (e.g., e1, e2, e3, etc.) representing the variance in each observed variable not explained by the latent variable it measures. These error terms ensure the model accounts for measurement error and unobserved factors.

Chapter 5

Summary and Conclution

5.1 Summary

The thesis explores the implementation of Electronic Document Management Systems (EDMS) in small and medium-sized enterprises (SMEs) within the Indian construction industry. The primary objective is to identify the success and barrier factors that impact the adoption of EDMS and to develop a hypothetical model tailored to these enterprises. This research is motivated by the need for digital transformation in the construction sector, where operational efficiency and timely project completion are critical. The study focuses on SMEs in the western region of India. The construction industry heavily relies on documentation, which traditionally involves significant physical paperwork, leading to delays and increased costs. To mitigate these challenges, the industry is increasingly adopting IT solutions such as Project Information Management Systems (PIMS), Enterprise Resource Planning (ERP) systems, and EDMS. Among these, EDMS is highlighted as the most suitable for document management due to its features like version control, document retention policies, and security measures. The literature review emphasizes the factors influencing the successful implementation of EDMS, such as organizational readiness, strategic alignment, customization, stakeholder engagement, and technological challenges. Key success attributes identified include the alignment of EDMS with business processes, commitment from top management, and strategic planning. Barriers to implementation include technological challenges, resistance to change among employees, lack of digital literacy, and inadequate management support. The research methodology involves identifying success and barrier attributes through literature review and expert surveys. Data is collected using questionnaires and analyzed using Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA), and Structural Equation Modeling (SEM). This approach helps in understanding the relative impact of various factors on the success of EDMS implementation in the targeted SMEs. The data analysis section ranks the identified attributes based on their significance and impact. The analysis reveals that factors such as top management support, employee training, and technological infrastructure play crucial roles in successful EDMS adoption. Conversely, resistance to change and lack of clear implementation strategies are significant barriers.

5.2 Conclusion

As demonstrated by the comprehensive study presented in this thesis, the successful implementation of Electronic Document Management Systems (EDMS) in the Indian construction industry, especially among Small and Medium Enterprises (SMEs), is affected by a variety of variables. This research employs an extensive literature review to identify and evaluate key success and barrier attributes, followed by empirical data collection and analysis using Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA), and Structural Equation Modelling (SEM). The paper stresses critical success factors such as organizational preparation, strategy alignment, stakeholder engagement, and the need for modification to suit specific project objectives. In contrast, significant hurdles include technology issues, employee resistance to change, a lack of digital literacy, and insufficient managerial support. These insights are crucial for SMEs in the construction industry to effectively navigate the challenging environment of EDMS deployment. The findings emphasize the significance of an optimized strategy that addresses the distinctive features and factors of Indian SMEs. By addressing both enablers and restraints, the research provides a solid foundation for strategic planning and execution of EDMS projects, ultimately enhancing productivity, collaboration, and competitiveness in the construction sector.

The study concludes that for SMEs in the Indian construction industry to successfully implement EDMS, there needs to be a concerted effort to align the system with organizational processes and ensure top management support. Customization of EDMS to fit specific project requirements and continuous training for employees are essential. Additionally, overcoming resistance to change through awareness programs and demonstrating the benefits of EDMS can facilitate smoother adoption. The developed hypothetical model provides a framework for SMEs to strategize their EDMS implementation, focusing on the identified success factors and addressing potential barriers. This model can serve as a guideline for SMEs not only in India but also in other developing countries facing similar challenges in digital transformation.

5.2.1 Future Research

Future research should focus on longitudinal studies to observe the long-term impact of EDMS implementation in SMEs as there is a significant impact of the barriers to successful implementation of the EDMS in the Indian construction industry. Comparative studies between different regions and types of construction projects can also provide deeper insights. Furthermore, exploring the integration of EDMS with other IT solutions like PIMS, and ERP can offer a more comprehensive approach to managing construction projects efficiently. In summary, this thesis underscores the importance of digital transformation in the construction industry and provides practical insights and strategies for SMEs to successfully implement EDMS, thereby enhancing their operational efficiency and competitiveness in the market.

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Annexure

Publications

1. Takshal J. Prajapati and V.H. Lad (2023) ”Identification of factors influencing the usage of electronic document management systems in the Indian small-scale construction industry” First National Conference on Modern Construction Practices and Management (MSPM2023), SVNIT Surat, 02-03 June 2023 (Paper presented)
2. Takshal J. Prajapati, V.H.Lad, and Lukman E. Mansuri (2024) ”Determining Success Factors and Barriers for Electronic Document Management System in the Indian construction industry” ARCOM 2024 40th Anual conference, UK, 02-04 September 2024 (submitted and Accepted)

Questionnaire Survey form

Institute of Technology, Nirma University
Department of Civil Engineering
Determining sucess factors and barriers for EDMS(Electonic Document Management System) in Indian construction industry.
Takshal Jagdishbhai Prajapati
M. Tech Construction Technology and Managenet, Semester -III
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Electronic Document Management System (EDMS) is a software platform that manages, stores, and tracks electronic documents and images of paper-based information. It provides a centralized repository for storing, managing, and sharing documents, facilitating better collaboration and productivity.
Questionnaire

Part- 1 Please put a tick mark (✓) on the relevant number to rate the following constrains (on five point Likert scale from not significant = 1 to extremely significant = 5) which affect the sucess of EDMS(Electronic Document Management System) in Indian construction industry.

Sr. No.	Success Attributes	Not Significant	Less Significant	Fairly Significant	Significant	Extremely Significant
		1	2	3	4	5
1	Project monitering & controling					
2	Improves decision-making processes					
3	Proper flow of information in organization					
4	Better coordination amongs stakeholder					
5	Clear chanel of communication					
6	User interface of system (easy to use)					
7	Quality output of information from system					
8	Framework of EDMS (Software configuration)					
9	Improves security of the documentation					
10	Fast and accurate data re-entry					
11	Software customization					
12	Accessiblity (Remotely accessible from anywhere)					
13	Reliability of EDMS					
14	Vendor & consultant support					
15	Quick data analysis and conversions					

Part- 2 Please put a tick mark (✓) on the relevant number to rate the following constrains (on five point Likert scale from not significant = 1 to extremely significant = 5) which affect the barriers of EDMS(Electronic Document Management System) in Indian construction industry.

Sr. No.	Barrier Attributes	Not Significant	Less Significant	Fairly Significant	Significant	Extremely Significant
		1	2	3	4	5
1	Substantial initial investment					
2	Lack of awareness					
3	Training/user lack proper training to use EDMS					
4	Resistance to change					
5	Lack of standardization					
6	Adequate software selection					
7	Lack of skilled user					

Figure 5.1: Questionnaire Survey form FS

Part - 3	**Please provide a feedback regarding the factors and their latent factors which have been mentioned here. And also suggest if there is any need to remove any factors/latent factors or to add any. Also you can provide the review from your view point related to the work carried out. Your feedback is extremely valuable for this research work.**	
Part - 4	**Respondents Information**	
1	Name	
2	Contact No.	
3	Email id	
4	Designation	
5	Experience (in years)	
Part- 5	**Organizations Information**	
1	Name	
2	Type of organization	
3	Experience (in years)	
Note:- This data will be used for academic purpose only and we will not be revealing any details of the respondents and organization .		
Date: __________________		
Place: __________________		
		Thanks for your Participation

Figure 5.2: Questionnaire Survey form BS

Resume

TAKSHAL JAGDISHBHAI PRAJAPATI

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BRIEF SUMMARY

To work in an environment that encourages me to succeed and grow professionally where I can utilize my skills and knowledge appropriately.

EDUCATION

Nirma University — 2022 - 2024
M.Tech. - Construction Technology & Management | CGPA: **7.78 / 10**

Asoit - Aditya Silver Oak Institute Of Technology — 2018 - 2022
B.E. - Civil Engineering | CGPA : **8.37 / 10**

St. Xavier'S High School, Hansol. — 2018
12th | GSEB | Percentage: **57 / 100**

St. Xavier'S High School, Hansol. — 2016
10th | GSEB | Percentage: **73 / 100**

INTERNSHIPS

NHSRCL (National High Speed Rail Corporation Ltd) | Infrastructure — 01 Jun, 2023 - 15 Jul, 2023
Project Engineer Civil
Worked as an Intern Project engineer for 6 weeks at MAHSR(Mumbai Ahmedabad High-speed Rail) corridor at C-8 package i.e. maintenance depot for the bullet train.

Arise group | Construction & Engineering — 08 Jan, 2022 - 10 Apr, 2022
Site Engineer
Worked as an intern site engineer on a residential project for 3 months.

Vinsystec Designers Academy | Construction & Engineering — 05 Jun, 2021 - 08 Jul, 2021
Site Engineer
Key Skills: AutoCAD | Revit Architecture
Planning and Designing of G+2 Storey residential building on AutoCAD and Revit Architecture.

PROJECTS

Determining success factors for EDMS(Electronic Document management system)in the Indian construction industry.
Mentor: Dr. Vishal Lad | **Team Size:** 1

PUBLICATIONS / RESEARCH / WHITE PAPERS

Identification of factors influencing the usage of electronic document management systems in the Indian small-scale construction industry
First National Conference on Modern Construction Practices and Mangemen. | **Mentor:** Dr. Vishal Lad | **No. of Authors:** 2
Key Skills: Presentation Skills | Communication Skills

ASSESSMENTS / CERTIFICATIONS

Autodesk AutoCAD

Autodesk Revit

SEMINARS / TRAININGS / WORKSHOPS

Crafting Tomorrow's World:- Strategic Project Management for Industry 5.0
Institute Name: Project managenment institute, Gujarat, India.

Modern Construction Practices and Management Conference
Institute Name: SVNIT

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