

Importance of Electronic Document/Information Management Systems in Modern Architectural, Engineering and Construction Projects

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Abstract— In this paper, the very importance of the usage of a proper electronic document or information management system for modern day Architectural, Engineering and Construction (AEC) projects is explored with appropriate case studies. While modern day AEC projects are global with multiple stakeholders involved in each and every project across the world, the sheer scope of these projects go enormously high but with limited time and resources. Main contractors, the sub-contractors, and the consultants are trying hard to keep up with the tight schedule in order to maintain their reputations and also sustain in their respective businesses. While traditional firms still use the older means of preparing and sending transmittals as a piece of paper and willing to wait for as long as possible to get the comments on their drawings, the need of the hour is to optimize the project management's triple constraints, that are, Time, Cost, and Scope of a project to ensure the Quality of the project is sustained throughout the project lifecycle. This is very much possible by using an apt and appropriate electronic document/information management system on the AEC projects which promises collaboration among various stakeholders involved in a project.

Key Words: Collaboration, Electronic Document Management System, Information Management System, Project Management Constraints, The Construction Industry.

1. INTRODUCTION

Let us picture a scenario. Imagine a room full of cardboard document boxes or rows of filing cabinets. You have a task to find one piece of document or a drawing or a file. The sure thing here is you might have to spend a lot of productive hours in searching the right document or drawing or file by looking through the various cardboard boxes and the filing cabinets. The worst and the unimaginable thing is there is a chance that the last person who pulled out that piece of document or drawing or file may never have put it back in its proper place. This is a regular and a default scenario at the sites and offices of the AEC companies that run their business over a longer period of time. This is a stark reality too.

Electronic Document Management System (EDMS/DMS) employs a computer system and software to organize, store, manage, and track electronic documents and scanned images of paper-based information [1]. Most systems allow users modify and manage to modify and manage the system and typically incorporate many physical filing procedures, such as storage location, security, access control, and version or revision control. One of the biggest benefits of maintaining electronic files is the ability to keep a record of who has accessed the content with details such as when was it accessed, whether it was downloaded or viewed or commented upon. With attrition rates sky rocketing in construction companies and competition galore among these companies, a tracking and monitoring system of documents play a very major role as it helps in protecting the copyrighted and proprietary information from falling on to unsafe hands.

Another important area where an EDMS can be of immense help in day to day construction operations is – group approvals, such as in estimates, proposal, design brief, contract document etc. In a traditional method, these approvals can take unexpected number of days that may lead to unprecedented delay in the progress of a project. With EDMS, the electronic version of the file can be shared that ensures the correct people review the document and can create an audit trail that allows everyone in the group to see another's edits while also preserving the document in its original form.

2. DOCUMENT MANAGEMENT AND THE CONSTRUCTION INDUSTRY

Modern day construction projects are wonders to watch and work with. Every one of these projects is filled with too many activities, too many packages, too many consultants, contractors, and sub contractors with not many of them knowing one another. Drawings, BIM models, contract documents, reports of all sorts, schedules, tenders, bid documentation, mail exchanges, approval processes – they have all got to move quickly and efficiently between project participants [2]. Many of the project participants have to work in real time with

multiple parties on complex projects in which case the traditional methods of printing and delivering hard copies, email exchanges, FTP servers do not work the way the participants want. Printing and delivering hard copies mean time delay depending on the logistics; email exchanges are good for day to day operational mails but have got its own limitations when the size of the attachments are too large to handle and there is no control over the versions or maintain an audit trail of them; FTP servers have storage limitations and unsecure protocols with no encryption.

Owing to the large volume of documents that are shared and exchanged during the course of AEC projects, it becomes a mandate to opt for a document management system that will offer document control for the entire project team, and save time with project-wide processes. Effective collaboration on a project is the need of the hour and this starts with effective management of document and information system where every project participate can access, retrieve and manage information on one secure platform. The hassles of having too many folders on your computers, alienated names of the documents which no one can understand except by the one that created, searching documents at the wrong place can all be avoided.

Not only is document retrieval efficiency increased with document management for construction, the fully automated system can actually help keep the administrative costs down [3].

3. CHALLENGES FACED IN MODERN AEC PROJECTS

Large scale AEC projects typically involve hundreds of stakeholders in an elaborate web of relationships, executing a complex sequence of tasks that has to be completed with pinpoint timing. Sometimes this complicated network of teams operates across wide geographical areas. Streamlined communication and collaboration are crucial to delivering these projects on-budget and on-schedule [4]. The various challenges that come out as a result are the following:

3.1 Organizational and Cultural Differences

Participants in AEC projects are often highly specialized organizations or firms with their time-tested unique set of best practices. Their management practices vary significantly because of the differences in ownership, areas of expertise, level of exposure, handling of resources, their

repute, and the value of book order. Their practices will change from project to project and from one site to another. More importantly there has always been a tendency to use different software, programs, and applications for their different tasks.

3.2 Short-term project driven relationships

All construction projects are unique in nature and the processes and procedures as well. When different consultants come on board to work together on a project, the compatibility of their corporate cultures or the existence of a prior successful working relationships are outweighed by factors such as cost, location and availability. Partners on one project may be competitors on another project which leads to an inherent lack of trust.

3.3 Higher stakes involved in AEC environment

Construction today is an unpredictable and high stakes endeavor. With thousands of contingencies large and small, the risk levels are very high and the pressure on margins is constant. AEC firms have to operate under greater scrutiny by regulatory bodies than ever before and need to demonstrate transparency and accountability. All these require costly layers of people, processes and systems dedicated to ensure compliances.

Under these unstable conditions, relationships between project stakeholders can quickly become adversarial and strained. Anything from a missed deadline to an actual defect can and frequently does cause a breakdown in relationships leading to costly delays and disputes or litigation.

4. THE NEGATIVE IMPACTS IN THE ABSENCE OF A DMS

The triple project constraints of project management will suffer a major setback if the challenges are not tackled properly, as shown in Table 1.

Table – 1: COST, TIME AND QUALITY IMPACTS

Action	Result	Impact
Inefficient communication between the project team	Delay	Time
Inability to	Delay	Time

locate drawings or documents when required		
Loss of important documents	Delay	Time & Cost
Works being carried out with outdated information	Disputes, delays, reworks, abortive works	Time, Cost, and Quality
Incomplete specifications and drawings	Reworks and abortive works	Time, Cost, and Quality
Non-compliance with site and works inspections due to incomplete or incorrect documentation	Delay	Time, Cost, and Quality

5.3 Powerful Search Features

The search engine of the chosen document management system must have multiple search features and/or criteria to search and retrieve documents at ease. Few systems offer “Advanced Search” or “Save search as” options which make search and retrieval an easier task.

5.4 Easy to use interface

The software or the system should be simple and easy to navigate as not everyone may be technologically inclined. Simpler the system, better will be the usage, efficiency and return on the investment.

5.5 Increases Productivity

The document management system should increase productivity by means of project wide processes.

5.6 Maximum Security

Security is one of the most critical and questionable aspects of a document management system. The ideal system shall provide a high level of document encryption, and offer role based access to various users.

5.7 Ability to model one’s own processes

An ideal system should have in-built business process management and workflows automation that automatically routes the documents to their destination based on the set processes. Also, the system should offer flexibilities to create and manage one’s own processes and streamline them.

5. CHARACTERISTICS OF AN IDEAL DMS

The following aspects have to be carefully studied before zeroing in on a particular choice of document/information management system [7].

5.1 Cross Platform Functionality

Access to the project’s documents should not be limited to a single device. It is important to ensure that the software is compatible with all the devices including computers, smart phones, tablets etc. An alternative is to choose an online SaaS (Software-as-a-Service) model of DMS which stores information on a third party server, where neutrality is maintained and where project participants can have access to these documents based on user control.

5.2 Document Scanning Capabilities

The ability to scan documents on to a database one at a time is a daunting task and a sheer waste of time. When selecting a document management system, careful thoughts are to be given whether it has got the ability to perform multiple documents scanning or operate through metadata such as Bulk Processing or Bulk Uploading.

6. DEFAULT OFFERINGS OF A DMS

As in any software or app, the DMS comes with a set of default offerings, which can be topped up with other offerings as well, based on clients or project’s needs. The day-to-day information exchange that takes place on a construction project may include but not limited to, mails, drawings, transmittals, approval process, searching and retrieval of documents, indexing and workflows. While these are standard offerings, in many cases, the project demands technological advancements like integration of BIM, using DMS as an app on the smart phones and tablets, accessing an online system offline as well, and real time collaboration. What makes a DMS, a successful element on a project, depends on how effective and efficient the document management processes do exist in the company.

Let us take a look at some of the standard offerings of a DMS:

6.1 Project Mails

This feature may sound similar to the conventional email system that everyone uses on a daily basis. The problems with the conventional mailing system is that tracking of emails may become a problem if the chain of communication is too lengthy, difficulty in sending documents or drawings of size more than 5 MB or 10 MB as the email exchange servers have got their own pre-set limitations, difficulty in searching and indexing emails, delay in approval or rejection processes, and ineffective log. **The “Mails” offering of a DMS caters to all the aforesaid problems and ensure everyone on the project is up to date. It can be configured in any way so as to suit the project’s needs and demands as it changes throughout the project lifecycle. This feature can be configured for RFIs, RFQs, RFPs, Change Orders, Site Instructions, etc.**

6.2 Document Management

The feature establishes a single location on the server where all the documents, such as, drawings, contract documents, tender bids, specifications, budget, project photographs and videos, BIM files, etc. This allows team members or any other stakeholder with appropriate user control permission to view, track and monitor these files. This feature also comes with a greatly effective search and indexing functionality, which helps anyone to track a document, does not matter, how old it is.

6.3 Workflows

Any modern day project involves at least one or two vendors from a foreign country. Imagine a document that needs to be approved or need comments on priority and imagine that document been sent on an email or through courier. Are we able to visualize how long this is going to take to get it done? May be a week or a month? Or even more? The workflow feature makes it as smooth as possible. **As the name indicates the project’s demands and needs can be customized into different set of workflows and for each workflow, the authorized personnel can be configured upon. The moment a workflow is initiated, the document passes from person to person as defined while setting up the workflow. This ensures everyone gets an email notification as to what needs to be done and by when. In modern day projects, where no one can afford to lose time, the workflows have really become a boon to the**

project demands. Collaboration on workflows can be done for RFIs, Change Orders, Approval/Commenting on a document, submittals, and any other customized or standardized forms.

6.4 Project Directory

The project directory hosts information relevant to the participants with their contact details, company name and designation. This feature offers easy retrieval of project **member’s information.**

6.5 Event Logs and Version Control

With attrition rate in construction industry looming and the need to uphold the copyright and proprietorship of documents and drawings are getting more attention, the feature of events log show a complete day to day detail about any document as to when it gets opened, edited, viewed, or downloaded. Few document management systems can be configured with digital signature to enhance security of the system as well as restrict users from accessing.

6.6 Searching with advanced features

Imagine being a document controller working on a large scale project. What would we visualize on entering the document storage room? Nothing but a massive cluster of documents, which will take a good amount of our productive hours to search and retrieve one document. The document management system readily offers search and advanced search functionality, which helps the user to search and retrieve documents and mails at ease.

6.7 Collaboration and real time commenting

This feature allows the team members across different geographies to share or open documents in real time and mark comments online. These comments can be saved as text or notes and can be shared with the team members.

6.8 Online Threads

This feature is like the “threaded” discussion on the conventional email system. This offers a sequential record of all mails and transmittals about a particular topic.

6.9 Project Camera

This feature allows the installation of cameras at proximal locations at the project site, which captures images at

regular intervals. All the captured images are configured to be stored in a repository within the DMS. These images can be compiled at a later date to serve as a marketing material or to make time-lapsed movies of the project.

6.10 Others

Some of the other value added offerings include printing service, file conversion with built in viewer, bulk processing using metadata, messaging outside the system, using the system on phones or tablets, archiving of the documents at the end of the project, and e-bidding.

7. CASE STUDIES

When we assess the importance of the presence of a DMS on a construction project, the numbers do matter. The numbers represent the number of users on a project, number of mails on a project, number of documents along with various revisions on a project; number of organizations involved on a project, total number of uploads and downloads on a project. When large projects are taken into consideration, the so called “numbers” will run into millions of documents and hundreds of users. Without an efficient document management system, handling and tracking of such a large number will be impossible. The following case studies show the importance of a document management system on major projects.

7.1 The Venetian, Macau, Hong Kong

The Venetian Macau is the largest single-structure hotel building in Asia and the third largest building, by floor area, in the world. It includes the world’s largest casino at 600,000 square feet of gaming space – as well as 3,000 hotel suites, 850,000 square feet of retail space, a 15,000 capacity arena and a 1.2 million square feet convention center. The challenges include high-value, high-profile project with hundreds of different organizations and consultants, including specialist firms, in China, Philippines, Singapore, Vietnam, Australia, the UAE, the US, Canada and the UK. At the end of the project, more than 3,000 project team members used the DMS [8] and managed over 2.7 million documents and more than 6.8 million project communications. Over 4.2 terabytes of project data were stored and managed.

7.2 Indira Gandhi International Airport, Terminal 3, New Delhi, India

The Terminal 3 or simply T3 at the Indira Gandhi International Airport occupies 520,000 Square meters and can accommodate 34 million passengers per year. It is over three kilometers long and includes 160 check-in counters, 78 aerobridges, and 85 aircraft stands. The Terminal 3 expansion project included a new runway, **Asia’s second longest. The crucial challenge on this project** was to complete the project with a compressed schedule of 39 months for the Commonwealth Games 2010. The project teams were dispersed globally with more than 70 organizations, with 45 outside of India. Other challenges that were faced were the limitations on the FTP sites, hard copies and email correspondences for project communications. At the end of the project, by using an effective DMS [8], the project team managed more than 300,000 documents and 1 million project mails, sometimes up to 100,000 mails per month. Every document and communication was accessible and searchable from remote locations; project members received notifications of new items and browsed tasks and actions in one place; the project was delivered on time for the Commonwealth Games.

7.3 Mandarin Oriental Hotel, Hong Kong

Mandarin Oriental International undertook a comprehensive renovation of its flagship property in Hong Kong. Built in 1963 and overlooking the Victoria Harbor, the Mandarin Oriental is an iconic institution in Hong Kong, **regarded as one of the world’s legendary hotels.** The renovation program repositioned the property by upgrading the facilities and services, while maintaining its, classic Chinese-influenced design. The major challenge on this renovation project was to shut down the hotel completely with the majority of the work focused on a nine month period. This clearly shows there would be no revenue during the shutdown period. The hotel started advertising to promote the reopening date which **eventually lead to “no margin for error in scheduling”.** The project team was large and dispersed across different geographical locations including Singapore, Malaysia and the UK. As they were working on a renovation project, chances were high that they might use outdated drawings. The project was successfully completed within the scheduled duration with the help of a proper DMS [8]. At the end of the project, the number worked out to be, 530 project team members from 82 different organizations

that managed nearly 500,000 drawings and communications. The dissemination of project information was reduced from 3 or 4 days to just a few seconds. The project implementation was fast yet thorough and complete.

8. TIPS FOR EFFECTIVE DOCUMENT CONTROL ON A PROJECT

While the aforesaid case studies clearly outline the necessity of a document management system on construction and infrastructure projects, the one reason behind the successful implementation and adoption of the chosen system is the way in which best practices are adopted to individual projects. Every construction project is unique and every one of them needs utmost care and design detailing. Once the drawings are transferred from the table to the site, the execution starts. Right from the conceptual stage, it is preferable to implement a DMS of choice and ensure proper configuration is done to the system, which will reflect the best practices of document control universally or will reflect the best practices of the type of construction project for which the system is chosen.

Either ways, to ensure a streamlined adoption and usage of the DMS, it is always advised to keep a tab on some of the basic key elements for effective document controlling [9].

Document Control in any project is a very critical case and failure to make use of it right from Day Zero of the project will have significant consequences over a longer run. Every project is like a pile of data and information which needed to be stored and retrieved easily. First and foremost, the engineers and the construction teams **“should have easy access to every single document”**, at any given time. In the absence of availability, the teams cannot work or will be forced to work with uncontrolled documentation. Secondly, the project team members and the engineers at the site have to be informed if there are any **“changes to the document/drawing”**. This change of field shall be intimated to the respective team members in a way or another. Thirdly, as every DMS offers, there has to be a way of **“marking up the changes”** on different versions of a drawing. This will allow project team members to identify the changes and work on the latest or the current version of any drawing or document. Fourthly, **the importance of creating a “document numbering system”**, which is very essential while using a DMS for better identification. The fifth tip will be to ensure a

document or drawings is **“superseded with the current version”**. This is where document numbering system plays a major role as the system cannot accept two different versions of drawings with same document number. Another important best practice is to mark the **“status of the document”** when it gets registered or transmitted. The status field will indicate whether the document is for approval, or for issue, or for commenting, or for construction.

9. PROBLEMS WITH DOCUMENT MANAGEMENT SYSTEMS

All through this paper, we have been seeing good things about the use of DMS for the betterment of project. But, on the flip side, there are few problems that lie beneath the successful adoption of a document management system.

For any system to be successful, adoption and collaboration are important. Whenever, a new project kick starts and the project team decides to subscribe or purchase or procure a DMS, the question that arise is, who is going to pay for the system. There are chances that one or more of the project team members may already be working on their own platforms and they may find it hard to shift to another system, for the sake of the project. This may eventually lead to one or few team members not **willing to use the system**, which leads to **“lack of collaboration”**. Lack of collaboration means no collaboration and the system will eventually fail. Lack of collaboration also leads to project failure. Keeping these things in mind, nowadays, even when floating the tender document to different consultants, a very clear and mandatory clause is appended to the tender document, clearly indicating the intention to use a DMS and sometimes with the exact name of the system as well.

Another issue with a DMS is the need for speed. A study by Akamai on its State of the Internet Report shows India at the bottom of the group. While the global average internet speed is 4.6 Mbps, the internet speed in India is just 2 Mbps. The average peak speed is 25.4 Mbps globally, **whereas India’s average peak speed is only 14.4 Mbps**. With such speeds, it would be a nightmare to use an online system to upload and download documents. When it comes to projects and project team members, it will be a mandate to either increase their internal bandwidth to use the chosen system or give it up. The moment, the team members or organizations give up, the adoption of the system is impossible and eventually leads nowhere.

There are also scenarios when the client chooses a system for tendering and pre-construction phase and then shift to another system during the construction and the post-construction phase. The result is waste of time and other resources and a lot of productive hours will be certainly needed to migrate the data from one system to another.

As Leonardo Da Vinci rightly says, "Simplicity is the ultimate sophistication", the project team members and engineers always prefer simple and flexible solutions that should be fast instead of a more complex and fancy system.

The interface of the system should be as better as possible with easy to use dashboards, which again, can be configured to the needs of a project. A beautifully designed interface with visually pleasing solutions will be the need of the hour.

10. CONCLUSION

It does not matter, which system should be chosen, but what matters the most is how much the project and the project team members can leverage the most out of it. The use of DMS is slowly picking up its pace in modern day complex projects in construction and infrastructure industry. The importance of using such a system on projects should be realized right at the conception level and necessary precautions are to be taken to ensure the project and the project team members will be benefited to the maximum. At the end of the day, we all strive to achieve the best possible results out of a project with the given time, cost and scope.

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BIOGRAPHIES



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