

Evaluation of Electronic Document Management (EDM) systems for construction organizations

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Abstract— It is crucial to adopt effective management system that can handle various information and documents in project activities. Electronic Document Management System (EDMS) is one such software which can use for document control, store, coordinate, retrieve and share information in electronic or paper-based format. There are lots of benefits of using electronic document systems in any organization. Some of them are security, user-friendliness, data visualization, reducing the cost for documents and increasing the quality of the project. However, Sri Lankan construction industry is very lag in adoption of these EDM Systems. Thus, this research aims to investigate the existing electronic EDMS and applicability of them in current Sri Lankan construction industry. In depth case study was carried out using one large construction project “Altair” to evaluate “Aconex EDMS” with requirements, challenges and benefits. Case study was carried out using a semi structured interview (6 Nos.) along with a questionnaire survey (24 Nos.). The results established that it is beneficial to appoint a separate staff member to handle the documents so that it will help to reduce the complexity. Further, it is identified that the greatest barrier to adopt EDMS in the industry is the lack of knowledge about EDM systems.

Keywords—*Electronic Document Management Systems (EDMS), Construction Industry, Management systems*

I. INTRODUCTION

Document Management System (DMS) is the use of computer systems and software to store, manage and track electronic documents and electronic images of paper based information. It can be further defined as a simple and efficient system which should be easily used by managers and other workers to save their effort and the time for the processing, storing, locating, coordinating updating, retrieving and sharing the information in between them. Many organizations in different industries have adopted EDMS in their operations as it enhances the efficiency and the productivity of the transactions. According to the Chia Hung, there are two main objectives of using EDMS in construction organizations. [1] It supports for the ubiquitous access. That means data can be easily accessed from anywhere any time and from any device with a simple knowledge of information technology. And also, it supports for the sharing and collaboration of data very easily and efficiently. Moreover, most of the construction companies expect to handle the schedule and budget through electronic document management systems.

However, there are lots of challenges over the benefits of EDMS in any organization. As per the research conducted by Ahmad, it is established that the main barriers of using EDMS in construction companies are the lack of IT infrastructure in remote construction areas, employee resistance, lack of

expertise and financial problems [2]. These barriers can be eliminated by identifying the requirements of the construction companies correctly and selecting the suitable document management systems appropriately. If not, entities will be unable to achieve the targeted benefits from the system. Therefore, through this research it is expected to identify the applicability of EDMS in Sri Lankan organization having identifying the benefit Department of Civil Engineering, challenges and the requirements to quit these challenges.

II. LITERATURE REVIEW

Normally, documents can be defined as a carrier of information that is used by the companies to inform, remember, instruct, certify, formalize and plan [3]. There are two types of documents namely electronic documents and paper-based documents which are circulated around any organization. When it comes to construction context document management systems may not be critical to the success of a construction project. However, it can't avoid documents and its management since they use documents from architectural plans to mark-ups to RFIs and one mistake in a single document can lead to costly mistakes in execution. It emphasizes that managing all those documents, in an efficient, organized way is very important.

The documents which can be categorized into electronic and paper should be managed in an efficient way to make the project successful within limited time and budget. For that, document management systems can be used. Document management system can be defined as the system which can coordinate and control the functions such as storage, retrieval, processing, printing, routing, and distribution of electronic and paper documents in a secure manner to be used by authorized persons effectively when required [4].

There are lots of benefits of using electronic document systems in construction industry. Some of them are security, user-friendliness, data visualization, reducing the cost for documents and increasing the quality of the project. The most important aspects of electronic document management systems are accessibility and security [5]. The documents should be accessed by only the authorized and legitimated users in that company. During the transit and store, the information should be protected with features such as authentication and encryption. Therefore, even if the hackers gain access to this links, they'll not be able to do that [6]. Further, electronic document management systems enhance the data visualization and increase the transability of information. This is very important when it comes to the financial management of construction organization [7]. Moreover, digital construction document management can help to improve the efficiency in many ways. It keeps track of current documentation easier by reducing the amount of paper copies and enables to access any project stakeholder. Graphical photos can be easily transferred

and move around the stakeholders and it enables to enhance the productivity of the project. Electronic document management systems can be further improved up to cloud-based systems combining with 3D modeling and that will give owners a better way to monitor progress, without taking any extra time. The benefits analyzed in this research were referred from the research paper “Investigation of Electronic Document Management Systems in small size construction companies in Jordan” as per TABLE 1 [2].

TABLE 1 – BENEFITS OF USING EDMS

Benefit 1	Less time is needed to retrieve documents or records
Benefit 2	The volume of paper records is reduced
Benefit 3	Using the EDMS speeds up my completion of work
Benefit 4	Co-operating with other departments become easier
Benefit 5	My office productivity has increased
Benefit 6	EDMS provides up-to-date information
Benefit 7	EDMS provides accurate information
Benefit 8	Easy to use even at the site
Benefit 9	Using EDMS enhances my effectiveness in the job.

However, there are challenges which should be overcome by construction industry if they implement document management systems in their organizations. The greatest barrier for this is the resistance to change. There is a high resistance from employees for a digitalized environment. Because of this it is very important to motivate employees to switch to the new system. Other than that, lack of top management support may lead to fail the system. When the top management doesn't like to shift from traditional environment to digitalized environment, then it is not advisable to operate an EDM system. Organizational structure is another factor which effects to the implementation of EDMS. Organizations should able to withstand the radical changes which need to make when it goes for digitalized environment. It should have the capacity of handling technical, human resources and organizational barriers. If any organization can manage these factors, EDM system will able to smooth the transactions and operations of any organization [2]. The challenges which analyzed in this research were referred from the research paper “Investigation of Electronic Document Management Systems in small size construction companies in Jordan” and “Evaluation of electronic document and record management program in a Canadian municipality” as per TABLE 2 [2] [8].

TABLE 2 – CHALLENGES OF USING EDMS

Challenges in adopting to new system (Challenge A)	Challenge 2	Unclear financial returns
	Challenge 5	Unwilling to change the routine process of work
	Challenge 6	Limited time in construction projects
Lack of resources which help to use EDMS (Challenge B)	Challenge 1	Expected high cost of electronic systems
	Challenge 3	Not interested in or lack of knowledge about EDMS
	Challenge 4	Lack of skilled employees on electronic systems
Benefits (Challenge C)	Challenge 7	Not convinced about its benefits
Security (Challenge D)	Challenge 8	Security of Information

To overcome the challenges mentioned above, requirements to implement successful Document Management System need to be identified properly. In 1996, Ejbe has shown that for a

successful implementation, motivation and training of users are an essential requirement. And also, in 2000 O'Brien has pointed out that there should be several groups with different types of skills and attitudes in a construction project to overcome the difficulties. Moreover, Antje has identified that the developers should more focus on the visualization aspect of the document management systems to have a clean and effective document management system [9]. In this research the requirements to mitigate the challenges were defined based on the research paper “Evaluation of electronic document and record management program in a Canadian municipality” by Li Xia [8] (See TABLE 3).

TABLE 3 – REQUIREMENTS TO MITIGAGE THE CHALLENGES OF USING EDMS

Requirement 1	It is important to have a staff person in each department with assigned responsibility to manage documents and records
Requirement 2	using the tilting guideline facilities document and records retrieval
Requirement 3	Assistance from RM department has been necessary for my understanding and use of EDMS
Requirement 4	The assistance for learning EDMS is very useful

After identifying these benefits, challenges and requirements as per TABLE 1, TABLE 2, TABLE 3, they were put in to a framework called “Acceptance model” to determine the acceptance of EDMS for an organization. This framework was developed based on the research “The effects of characteristics of Electronic Document Management systems on their Acceptance: an empirical study in Jordan” by Haitham H. AlShibly. In there, four characteristics namely “perceived system quality”, “perceived information quality”, “perceived usefulness”, “perceived easy to use” variables were used for the acceptance of EDMS. “Perceived system quality” defines the users’ evaluation of an information system from the technical and design perspectives and “Perceived information quality” defines the users’ reaction to the characteristics of output information Vs the users’ information requirements. Further, “Perceived usefulness” implies the person’s subjective perception of the effortlessness of a computer system and “Perceived ease to use” implies the degree to which a person believes that using a particular system would be free from physical and mental effort. The acceptance model which is developed in this research is basically derived from the above explained framework and it is shown in Fig 1.

III. METHODOLOGY

A case study based on a questionnaire and a semi structured interview were carried out in one of the leading construction projects” Altair” - Sri Lanka using the EDMS “Aconex”. The method “case study” is used for the evaluation due to the fewer companies were using EDMS “Aconex” in Sri Lanka and sample size in a case study need not to be larger in breadth but the considered points should be in depth. Further, when compared to the written survey and interviews, case study and empirical method can be used to the statically invalid sample sizes. [10] [11]

The project was basically controlled by three parties: consultant, client and contractor. All the users who use EDM system among all the employees in each party; contractor (4), consultant (13) and client (7) were taken as the sample (24 Nos.). The project managers, site engineers, marketing managers of the project, documents controllers (draftsman)

who used Electronic Document Management Systems were selected as the sample (See TABLE 4).

Semi structured interview was done with 2 members from each party to identify the background of each company (users of EDMS, Number of accounts for each construction company, Number of document controllers in each company). Further unique challenges, benefits and requirements for EDMS “Aconex” which were identified from interviews are checked with benefits, challenges and requirements in literature review (Table 1, Table 2, and Table 3).

TABLE 4 – SELECTED SAMPLE

company	Short form included in X axis of the graph	Number of users
Contractor	CT	4
Consultant	CS	13
Client	C	7

The company type is shorten in the X axis according to the TABLE 4 and each member in each company has been identified as CT1, CS1 and C1 for easiness.

The questionnaire was developed using requirements, challenges and benefits which were defined in TABLE 1 (Requirements to mitigate the challenges of EDMS), TABLE 2 (Challenges of EDMS) and TABLE 3 (Benefits of EDMS). And the interviews were done with senior management staff regarding details of the project, companies participating in project, number of users of Electronic Document Management System and total number of employees in each company. Then, according to the “Acceptance model” described in literature review, the theory was defined in this research (See Fig 1).

According to the framework, the analysis can be categorized in to three parts as shown in TABLE 5.

TABLE 5 – CATEGORIZATION OF ACCEPTANCE MODEL

Category A	User accounts and Users
Category B	The effect of experience and knowledge level of users for the acceptance of EDMS in project “Altair”
Category C	Effect of challenges, benefits and requirement for the acceptance of EDMS in project “Altair”

The background about using EDMS was analyzed in Category “A” to identify the difference between number of employees, users and user accounts due to the limited budget and the actions taken to mitigate the issue “limited account”. “Perceived information quality” which defines user’s reaction to the electronic document management system was categorized in to two namely knowledge level and experience level. This variable was analyzed in category “B”. Further analysis was done to check the actions which are taken by employees to mitigate the issues identified in the category “A” is efficient or not. “Perceived system quality” which defines the information system (EDMS) was categorized in to two; challenges and benefits. Then, requirements which need to minimize the challenges are introduced under “Perceived ease to use” and “Perceived usefulness”. Category “C” was used to analyze the challenges, benefits and requirements which can be identified when using EDMS. This category was further analyzed to evaluate the effect of challenges for the background of the project analyzed in category “A”.

After that, the data was analyzed and put in to the acceptance model to determine whether the EDMS should be accepted in this project or not. The results can determine whether the same type of project should use the EDMS “Aconex” or not to make their work efficient.

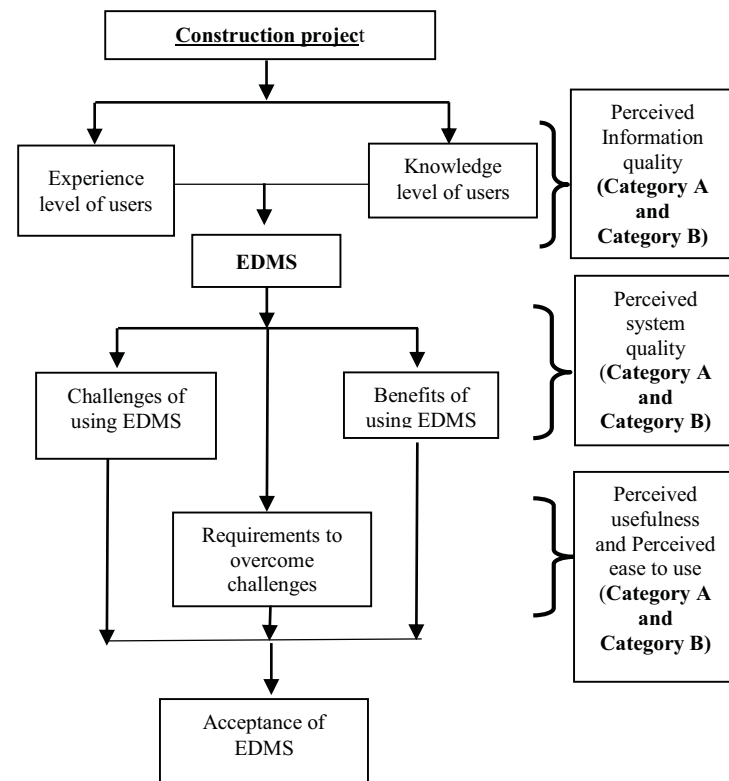


Fig. 1. Acceptance Model of EDMS

IV. SUMMARY AND DISCUSSION

A. User accounts and users

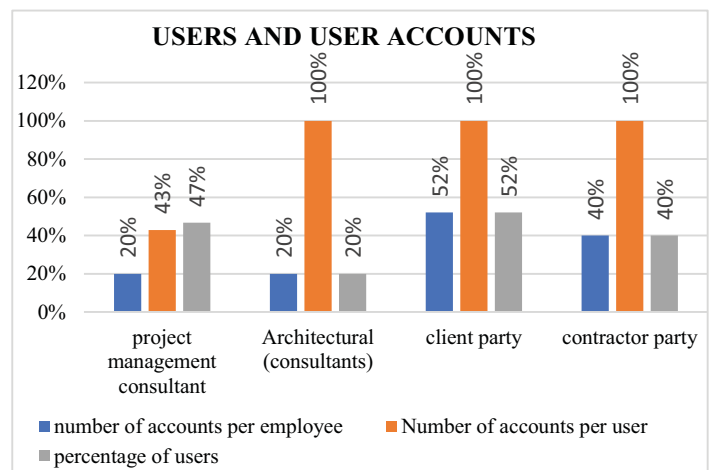


Fig. 2 . User accounts and Users

The X axis of this graph in Fig. 2 has been defined as the types of companies participated in this project “Altair” and the values of Y axis as percentages. And the graph implies how the users in each company operate EDMS with the user accounts. It is identified that all the companies except “project management consultant” team has got 100% for number of accounts per user. Companies have used limited number of accounts with the goal of reducing cost. However, it is not acceptable to share limited number of accounts with so many users for an effective management. To mitigate the issues of insufficient number of accounts, the “Project Management Consultant” has appointed position called “Document

Controllers” and all the document users have to share the documents through theses controllers. That helped them to reduce the issues in the “Aconex” EDMS.

Further, according to the Fig. 2, it is identified that companies have tried to maintain sufficient number of accounts. Along with that, the overall cost of the project also has gone up. Therefore, it is concluded that it is better to provide optimum number of accounts per user for an efficient management system.

B. The effect of experience and knowledge level of users for the acceptance of EDMS in project “Altair”

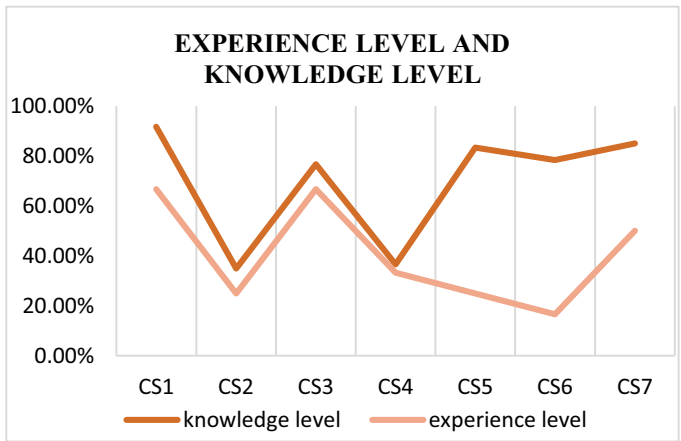


Fig.3. Experience Level and Knowledge level

Fig.3 shows how the experience and knowledge level of the users’ effect to handle the EDMS systems. In this graph X and Y axis can be defined as the users of EDMS in project management consultant team (See TABLE 4) and the calculated percentages of knowledge and experience level according to the distributed questionnaire. According to that, experience level and the knowledge level of the employees in the consultancy company shows approximately a same variation but, always the knowledge level in every user is much higher than the experience level. When this is further analyzed it is clearly shown that there are three peaks and they are owned by the “Controllers of EDMS” indicating that the knowledge level and the experience level of the controllers are much higher than the other users.

Therefore, it is concluded that to have a better EDM system it is necessary to have required knowledge and experience about the system and its operations. “Altair” project has optimized users by appointing “Controllers” with sufficient knowledge and that can be recognized as a positive trend towards effective management of EDMS.

C. Effect of challenges, benefits and requirement for the acceptance of EDMS in project “Altair”

1) Variation of cost and benefits over experience and knowledge level of respondents

As shown in Fig.4, the X axis can be defined as the users of EDMS in each company (See TABLE 4) and Y axis is defined as percentages of cost, benefits, experience level and knowledge level. This graph implies the variation between cost and benefits of using EDMS “Aconex” in this project “Altair”. The actual value of using EDMS should be considered according to both cost and benefits. Therefore, challenges (See TABLE 2) and requirements (See TABLE 3) are considered under cost and benefits according to the TABLE 1 [10]. It is

identified that the users of EDMS “Aconex” except three have accepted that there are more benefits than its cost. As the other three users have lesser knowledge and experience level the responds can be ignored.

However, it is concluded that though companies have to invest considerable amount on EDMS “Aconex”, the Benefits over Cost ratio is considerable high because of the productivity and the effectiveness which is derived through the system.

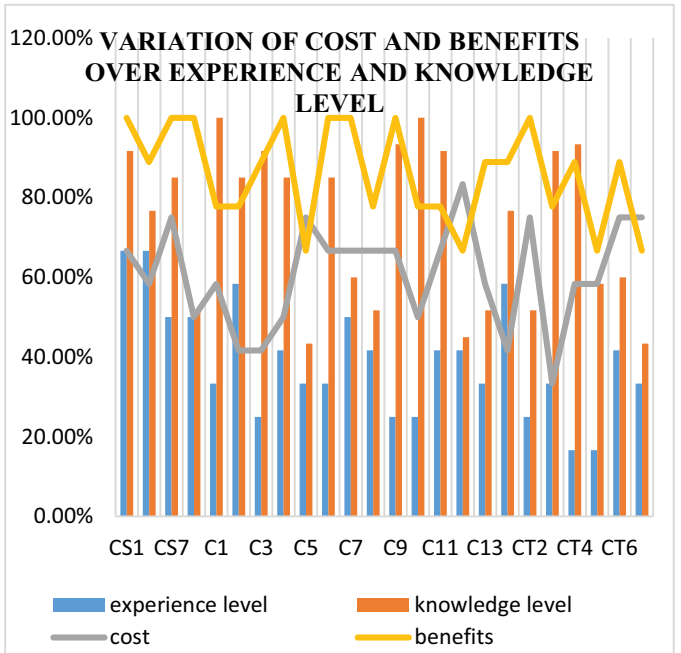


Fig. 4. Variation of cost and benefits over experience and knowledge level

2) Variation of four types of challenges

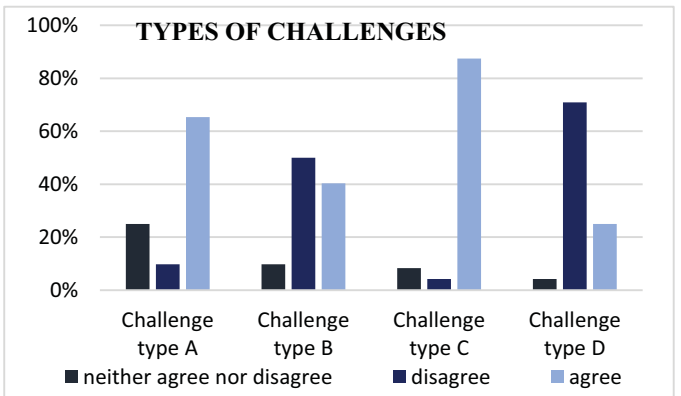


Fig. 5. Types of challenges

According to the Fig.5, the X and Y axis of the graphs are defined as the types of challenges and calculated percentages of responds for each challenge type. This graph shows the variations of responds for the challenge types by the users of EDMS “Aconex”. Challenges are categorized in to four types; challenge type A (Challenges in adopting to new system), challenge type B (Lack of resources which help to use EDMS), challenge type C (Not convinced about the benefits) and challenge type D (Security of Information). According to the graph (See Fig. 6) many users don’t agree with the challenge type B (Lack of resources which help to use EDMS) and challenge type D (Security). But challenge type A (challenges in adopting to new system) and challenge type C (not convinced about the benefits) are accepted by many respondents. Therefore, it can be concluded that there are difficulties when

adopting to new systems at the beginning and many users don't recognize benefits of EDMS (Aconex) properly. And the greatest challenge of EDMS "Aconex" was recognized as the challenge type C "Not convinced about the benefits of "Aconex".

3) Variation of challenge types according to the experience and knowledge level of respondents

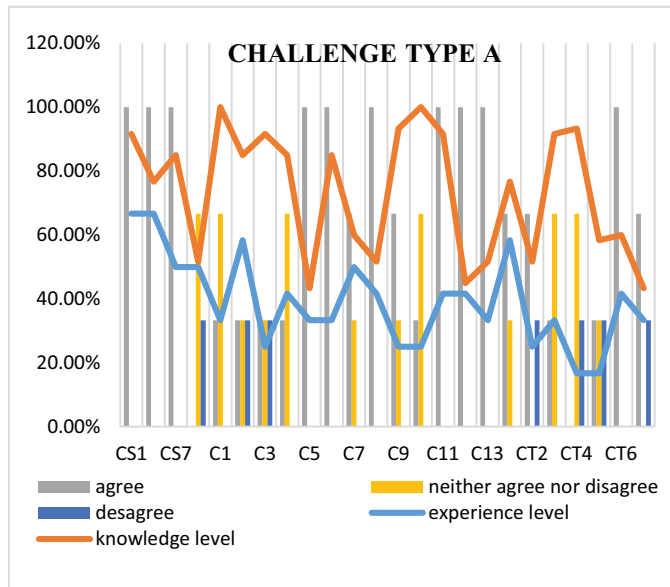


Fig. 6. Variation of challenge type A with experience and knowledge level

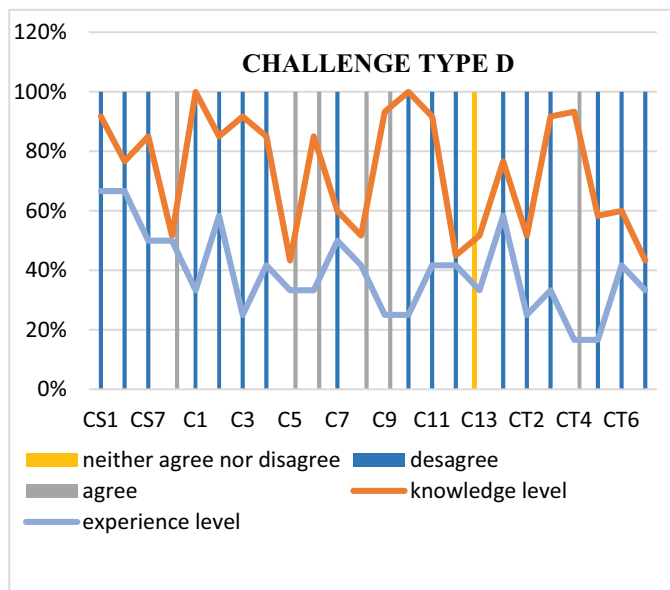


Fig. 7. Variation of challenge type D with experience and knowledge level

The variation of challenges which might be affected to the system used in Consultant Company (analyzed in category A) in project was selected from questionnaire survey. According to the interviews, among all four categories, one challenge type was completely denied and one was completely accepted by them.

The acceptance of each challenge by the respondents in project management consultant team who has optimum number of user accounts is highlighted using these graphs. It is identified that most of the users are accepting that it is challengeable to adopt to a new system at the beginning. And a greater number of employees deny that security of documents is a challenge.

The most highlighted detail in these graphs is that the users in project management consultant team (CS1, CS3 & CS7) don't have a problem with the security of documents though they use limited number of user accounts. But they have identified that adopting to new systems is a challenge because the controllers and other users have different experience and knowledge level.

Therefore, it can be concluded that security is not an issue to have an optimum number of user accounts in EDMS "Aconex" in this project "Altair" but the company should be able to minimize the effects of having experience and knowledge gaps between the employees.

4) Variation of Benefits

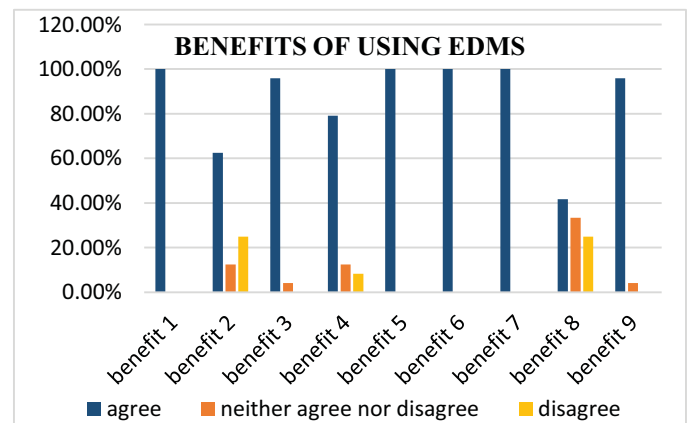


Fig.8. Benefits of using EDMS

The graph (See Fig.8) shows the variations in the benefit acceptance (See TABLE 1) of EDMS "Aconex" according to the users of EDMS in the project "Altair". The acceptance of the users of "Aconex" is shown by the Y axis and types of Benefits (TABLE 1) are shown in the X axis of the graph. (Fig. 8)

It is identified that the benefit 1, benefit 5, benefit 6 and benefit 7 have been taken 100% of responds. There are some uncertainties in responding for benefit 3 and benefit 9. But benefit 2, benefit 4 and benefit 8 are rejected by considerable number of respondents.

Therefore, it can be concluded that using EDMS "Aconex" helps to retrieve documents or records in less time, increase the productivity in the company, have up-to-date information and have accurate information. However, by having an EDMS as advanced and efficient as "Aconex" the volume of paper records won't be reduced because the contracts, bills and drawings should be taken as hard copies for the easiness of site engineers and quantity surveyors. With increasing of paper documents, the problems in sharing will also increase. But as mentioned in the graph (See Fig.4) the benefits are higher than costs, the EDMS "Aconex" can be accepted by providing the facilities to have paper documents for those who actually need it.

5) Variation of Requirements

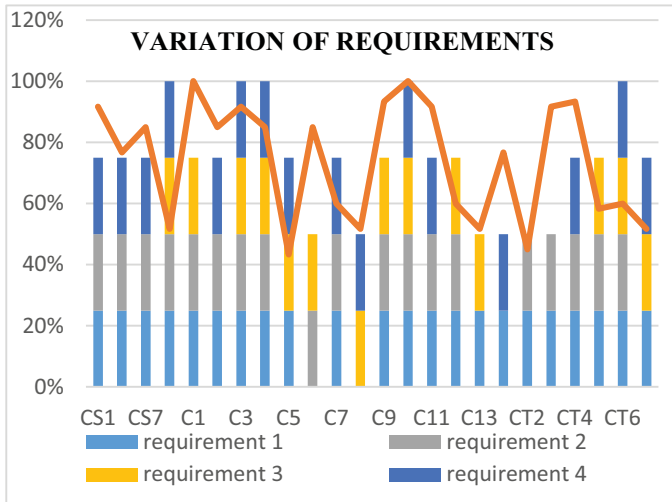


Fig.9. Variation of the requirements of EDMS

This graph (See Fig.9) shows the variation of responds for the requirements (See TABLE 3) to mitigate the challenges of using EDMS “Aconex”. The Y axis of the graph shows the percentage of acceptance level of the users of EDMS “Aconex” and X axis shows requirements indicated in TABLE 3.

It is identified that most of the users have accepted requirement 1, requirement 2 and requirement 4. Therefore, it can be concluded that every company who are using EDMS “Aconex” should have a staff person in each department with assigned responsibility to manage documents and records as the basic requirement to solve the problems when using the EDMS. But it is not cost effective to have a staff member for extended tasks like record management of departments in a construction company.

V. CONCLUSION

By considering about the facts, overall acceptance of EDMS is high according to the responds of users in each department and each company who contributed to this project. But there are some requirements and improvements that should be added as they responded.

- Document controllers should be the users who have higher knowledge and experience levels.
- By using EDMS, benefits can be achieved than facing challenges.
- There are challenges in adopting to new system and lack of knowledge about EDMS’ benefits.
- Security problems, time and cost wastage cannot be accepted as challenges.
- Benefits which can be achieved by the EDMS depends on the type of department. Many paper documents of drawings and bills are produced, and the **paper document reduction cannot be done easily**.
- During the constructions paper documents of drawings are easy to use than EDMS and soft drawing files at site.
- Some companies working in the project don’t have user accounts as the price of EDMS package increases with number of user accounts. Therefore, documents sharing should be done through emails with them and that make the working process complicated.
- If the users are lack of knowledge and experience in EDMS, some assistance and tutorials should be done at least in the beginning.

These problems can be reduced using EDMS by limiting the user accounts, functions according the budget of the project makes the work more efficient than paper work.

However, as the “Altair” project was consisted with matured people the tendency towards EDM was very low. Therefore, in this project “the top management knowledge as not at required level to use EDMS systems “was proved with the questionnaire analysis.

Further, by considering these facts the projects which shows the same information quality as project “Altair” can make decisions to use EDM system “Aconex” for their project. The projects that don’t show the variation as project “Altair” can follow the case study structure and make decisions to select a better EDM system.

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