VISUAL INFORMATION ACCESS AND MANAGEMENT FOR LIFE CYCLE PROJECT MANAGEMENT

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ABSTRACT

The construction industry suffers from a lack of sophistication in information management practices causing costly delays and changes to occur often. Although there have been many information technology (IT) applications developed for the Architecture, Engineering and Construction (AEC) industry, construction information remains fragmented even among members of the same team. One of the possible solutions is to use information technology to control, document and communicate construction information. To fully benefit from any new technologies, a lifecycle approach is required to link the construction information and knowledge among the different parties during the life cycle of the construction project.

Managing project information during the construction phase is an important yet difficult task. Construction information management must support many tasks performed by different participants, as well as integrate these tasks by supporting information flow between them. Good information management ensures that knowledge or lessons learned are fed back to the management team for future improvements and that up to date as built information is available for facility operation and maintenance.

The focus of this study is on the construction phase and the objective of the proposed visual model is to establish an information framework which supports lifecycle information integration among participants and organizations throughout the life cycle of the structure.

KEY WORDS

Project Lifecycle, Information integration, Visual Representation, Information Management, Facility Operation and Maintenance.

INTRODUCTION

The construction industry is very fragmented since it involves different teams that cooperate and complement each other in order to bring an end product to life. The main challenge that faces this industry is the requirement that these parties with different backgrounds, levels of education, levels of technologies adaptation, communicate and coordinate in order to integrate the information needed to accomplish a common goal.

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The construction management team, referred to as the expert in the construction processes, is a party that acts on behalf of the owner to manage the construction activities. Their main task is to document the work processes on site and to assure compliance with the contract documents, local codes and best practices.

In an age of computer technologies, where industries are adopting new technologies to achieve competitive advantage, the construction industry, so far, has been resistant to change, and is lagging behind the rest of the economy. Even though, the different parties involved in the construction process rely on computers to perform their own tasks, the exchange of information amongst them is paper based. In the last decade, advances in computer technologies have provided different applications to separately assist the different teams involved in the construction process. As a result of these technologies, the construction industry suffers of what can be described as islands of information that lack the connectivity needed in order to fully benefit from the advances in information and computer technologies.

In an attempt to link these islands of information between the different parties involved in the construction process, a huge effort has been vested in developing Industry Foundation Classes-IFC -standard data structures in order to allow computer applications to exchange project information about construction projects. Approaches such as Object Oriented Computer Aided Architectural Design (OOCAD), and Life Cycle Management (LCM) are also believed to improve building information modeling and communication, in the AEC industry.

The focus of this study is on the construction phase and the Construction Management team (CM), in particular, to improve building information and its flow and communication through out the life cycle of the project. The construction management team is studied as two subgroups; the “project management team” and the “On site/ field team”. This study suggests a comprehensive, integrated, flexible computer-based visual model that will increase the efficiency of information exchange, and a framework which supports lifecycle information integration among participants and organizations throughout the life cycle of the structure.

BACKGROUND AND PURPOSE OF THE STUDY

THE DIFFERENT STAGES OF THE FACILITY

The members of the construction management team and their roles vary throughout the different stages and phases of the project. The project life cycle starts with the planning stage; at this stage the involvement of the construction management team is basically to help the designing entity come up with the final model that will satisfy the need of the owner, within the feasible approved budget. At the early phase of this stage the members of the construction management team involved in the process is the estimating department and the executive management of the construction company. In this stage the management team relies on historical data from previous projects in order to help determine the most probable range of costs for the facility, as well as the best practices and materials to be used in order to assure that the final cost of the facility is as expected by the owner. The second phase of the first stage is the preparation phase, where the feasibility study is completed and the final model is developed, hence a complete cost estimate is produced. At the end of this phase the construction management team takes the 100% complete model, referred to at this time by "the contract documents" to the approval phase where the construction management team will proceed to get the permitting with the local authorities as a first step towards the proceedings with the second stage of the project, the executive stage.

The construction team at the first stage of the project is in need of a reliable up-to-date database that will provide the correct estimates of costs based on previous projects. The more detailed the data is, the better the cost projection will be for the new project. This preliminary estimate as well as the different suggestions for the choice of materials and practices would be supplied from previous and ongoing projects.

The second stage of the project is the executive stage, and consists of two phases. The first phase is the personnel mobilization. In this phase, the Executive management team will select the construction team that will be on site to oversee the construction activities. At this first phase of the second stage, the construction team will be in charge of developing a detailed estimate and the schedule is broken down to the very details that will be assigned to the different subcontractors involved in the construction activities. The respective responsibilities of the team members and the timeline guidelines to the different construction activities will also be defined. The second phase of the second stage would be the implementation phase, where the subcontractors are selected and the contracts are awarded. The onsite mobilization take place and the initial operations starts leading the way to the third stage of the project, the ongoing operations stage.

The construction team at the second stage of the project uses estimating software and scheduling software to set the pace for work progress as well as being able to divide the work in group of tasks that will be parts of the subcontractor's contracts. The breaking down of the tasks into the different contracts would be a major challenge for the construction team, as any omitted activities would be the responsibilities of the construction team.

The third stage of the project is the ongoing operations stage, and consists of two phases. The first phase is the implementation phase and ends with the completion of the full operations, and extends to a one year warranty period for the facility. In this phase the construction management team's main challenge is to enforce the contracts, and assure quality control for the work in progress; to document the work and the paperwork needed for the liability as well as generate reliable data to be used in future projects biddings. The second phase of the ongoing operation's phase is the responsibility of the maintenance and operation crew.

The construction management crew at the third stage of the project needs a comprehensive, yet flexible database to access the project information and communicate the work progress, monitor changes and coordinate the onsite work progress, keep a log of the onsite work activities and generate pay applications to bill the owner and pay the subcontractors.

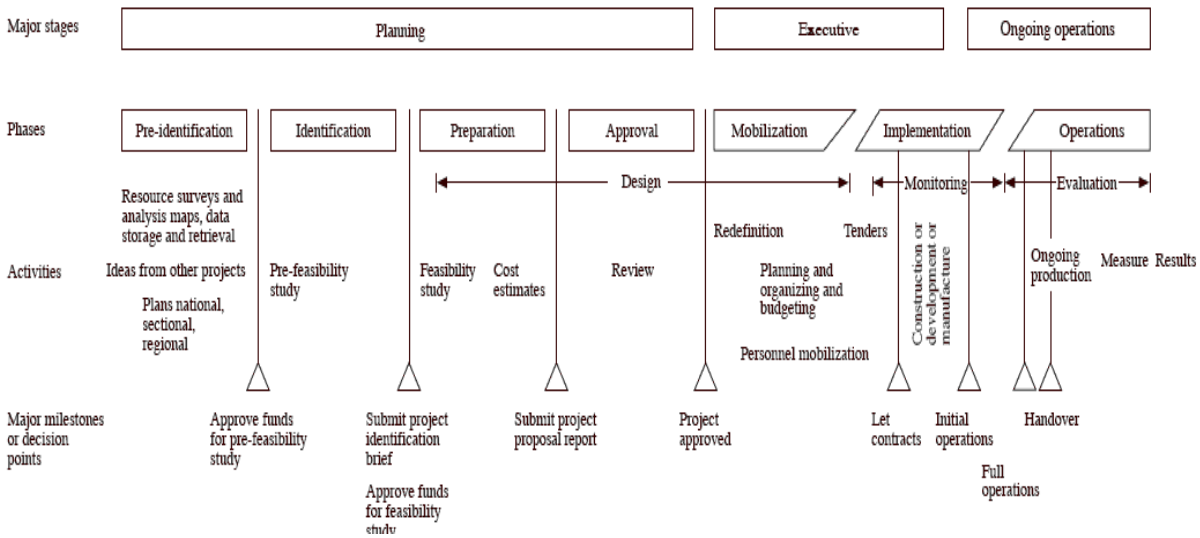

Figure 1: The Different Stages and Phases of A Facility, (Figure 10 in Expert Project Management – Modeling Project Management)

The Construction phase

The construction team at the construction phase is formed of two different entities, the management team and the field team. These two entities need to continuously cooperate and exchange the information they generate to assure accurate, reliable and up-to-date information to be shared among the same construction team as well as the different parties involved in the construction of the project.

The project management team's main responsibilities are to issue and monitor subcontracts, maintain project files and logs, prepare close out documents, monitor cost and changes, and take charge of the formal correspondence with the owner and Architect. The construction field team on the other hand, has different responsibilities as to manage on site construction activities, assure quality control of work performed in accordance with the contract documents and local codes, develop the schedule for the work progress, keep daily logs to report on site work progress, schedule and coordinate inspection and testing materials.

The information on the schedule generated from the field crew will be used by the management crew to maintain and continuously monitor the cost of construction progress and payment control. Daily reports are generated along with pictures to keep track of activity progress. Inspections are performed to check if the on-going/completed construction work complies with the requirements. Punch lists are made to keep track of any defects or damages during construction, and they are reflected in progress payments.

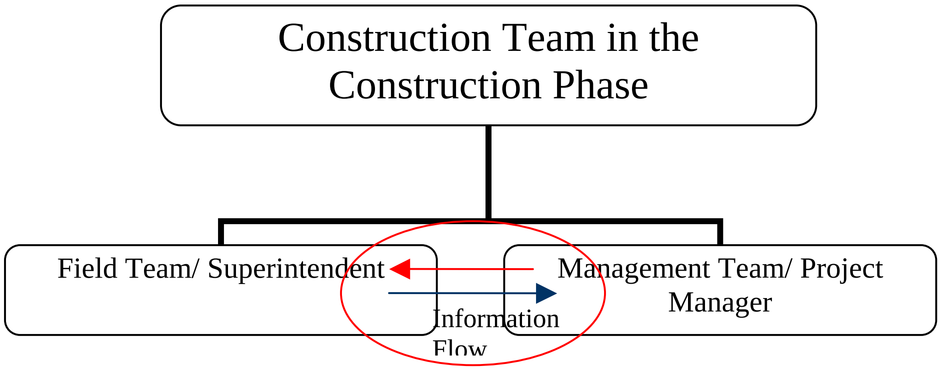

Figure 2: The Construction Team in the Construction Phase

The communication between the same construction team's subgroups and the different subcontractors is paper based as it is the least common denominator between the different parties with different technologies adoptions and adaptations that are involved in the construction process. Also the paper based communication is considered the official legal way of communication, signed, sealed, and dated.

Managing project information during the construction phase is an important yet difficult task because of the necessity of bridging the design phase and the facility use phase. Construction information management must support many tasks performed by different participants, as well as integrate these tasks by supporting information flow from one to another. Also, good information management ensures that knowledge or lessons-learned is fed back to the designers for future improvements, and that up-to-date as-built information is available for facility operation/maintenance.

The Construction Project Information

The information collected to document the building components, activities, costs, material, labor, contracts, inspection logs, changes and many other types of information, takes various formats, such as submittals, change orders, requests for information, daily reports, photographs, etc. As the project progresses, the volume of the information generated increases to large amounts of information that, towards the completion of the project, amounts to a room full of construction documents in boxes that is turned over to facility operators/maintainers.

Currently, information exchange between the phases of a facility life-cycle and between different participants of a project is not ideal. Information exchanges are typically paper-based, and the parties during each phase of the life-cycle spend time and effort to manage information manually, even though almost all organizations involved in facility design, construction, and operation and maintenance rely on computers to perform their tasks. Opportunities and challenges exist in establishing an information framework which supports life-cycle information integration among participants/organizations throughout design and construction to operations and maintenance.

THE PROPOSED VISUAL MODEL

Due to the fragmented nature of the construction team and the lack of a computer tool that can efficiently assist the construction team with the diverse tasks they need to handle, the construction management team still relies on the old fashioned practices awaiting a solution that can bring the construction industry up to speed with the rest of the economy. Keeping in mind that the computer knowledge of many of the construction team members, especially the field team members, remains basic compared to their extended knowledge in the construction trades and practices. Hence the idea is to provide the construction team with a tool that will not require the team members to change their common practices, neither to adopt new practices, but instead provide them with a structure that organizes their input in a template database that will allow the different participants to share and benefit from the other team members' contribution. The database will allow the different team members to view and/or modify information based on their roles and level of involvement in the construction activities.

CHARACTERISTICS OF THE SUGGESTED MODEL

The proposed integrated construction project information model is developed with the intentions to facilitate management of activities throughout the life cycle of a construction project, using a Database that integrates graphic drawings and textual databases. The advantages of the suggested model is that textual information is accessible from the drawing, (by point and click) as well as having the ability to view the graphical representation related to textual information in the database, creating a two way connection between the graphical and the textual information. Figure 3, is an illustration of a 2D CAD drawing linked to a table that stores information related to the different construction elements.

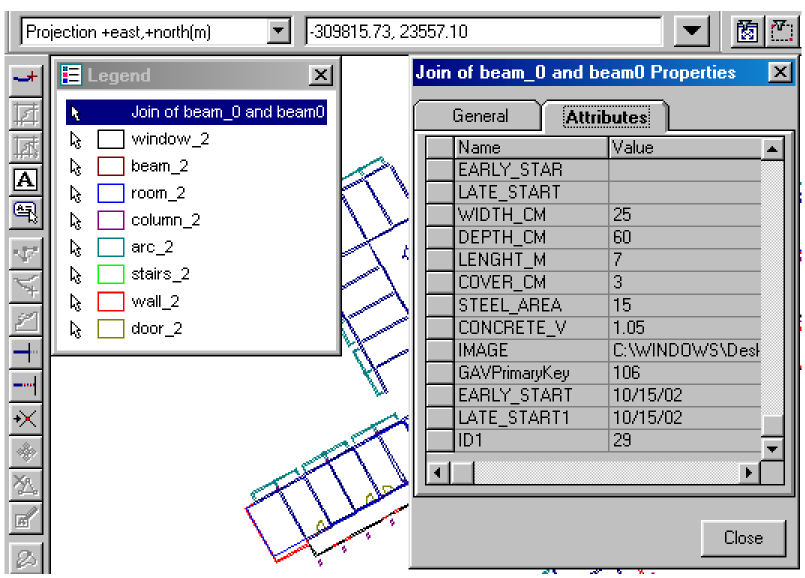

Figure 3: The Two Ways Connection between the Graphical and Textual Information

The 2-Dimensional (2D) drawing as well as the paper based communications seems to be the least common denominator among the different teams involved in the construction phase of the project life cycle. Even though unsophisticated, reliance on the 2D representation of the facility is a general practice in the construction industry. The suggested approach in this model is to integrate graphic objects and textual databases in order to allow the user to store and execute database scripts and queries, as any other database. The drawings and the textual information are tied and interconnected allowing scripts, query files, and database references to be processed using a Structured Query Language (SQL). SQL allows visual query languages to express complex queries in a visual, less unsophisticated way.

The 2D CAD drawings provided by the Architect would be organized such that all the construction elements have a unique ID. This ID would be referred to in the database warehouse linking this graphical representation of the construction element to a set of attributes related to the particular construction element. The advantage of doing so, will allow the user to access information related to the construction element without the need to look for the information in different sources, saving the end user time to locate and assimilate the information. For instance, the doors as construction elements in a facility would be organized in a layer specific to the doors. A table would be associated with this 2D drawing, connecting each one of the doors based on its ID to the different attributes that are related to the particular construction element.

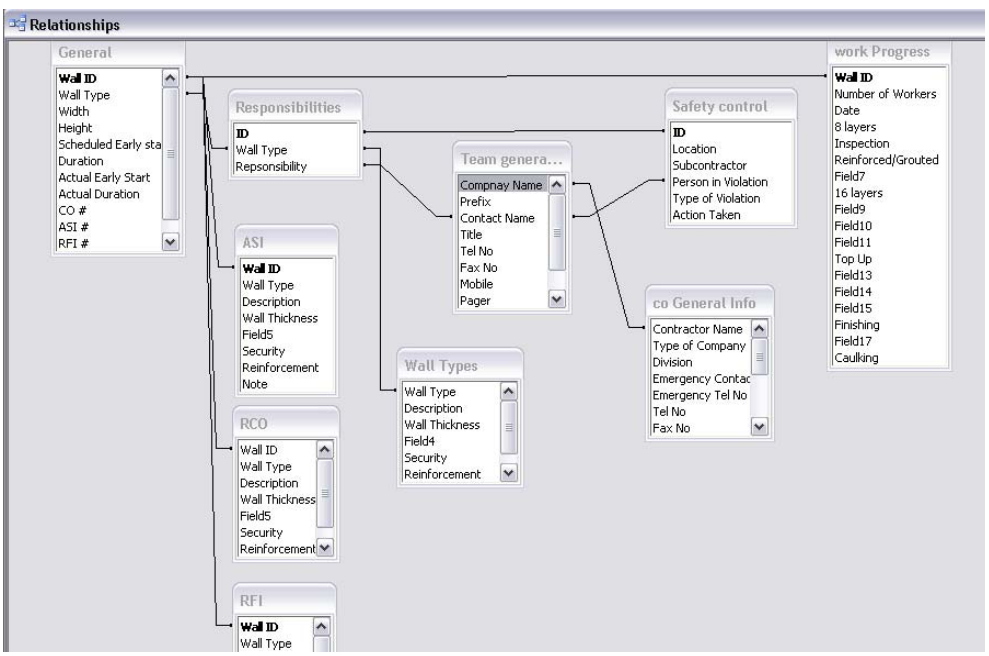

Figure 4: Different Tables Interconnected Through the Common ID for the Construction Element

As shown in Figure 4, the database constitute of separate tables interconnected by the mean of the unique ID of the construction element. As shown above, each wall will have a unique ID. The different tables will be linked to the CAD drawing through this ID. The different tables will represent the different pieces of information related to the particular construction element. All the tables are integrated in the one complete database to manipulate the data and generate information useful to future project, evaluation of work practices, lessons learned and other decision management information.

This process will allow the user to access the information specified in the contracts documents to the related constructions elements. But in order to achieve the full benefits from the perspective of the construction management team, the model will need to provide the documentation, facilitate the communication and provide the feedback for future projects. In order to fulfill these tasks, the database will have additional tables that are specific to keep track of the common practices of each one of the construction team members. For instance, the field Superintendent would be assigned a table dedicated to keep track of the door related activities, in these table will include the different information to the different levels of details needed to fulfill their task. The management team will also have their own table in which they record and input the information they generate related to these particular construction elements. The two separate tables are interconnected to each other and to the 2D CAD drawing information in both tables can be accessed from point and click on the drawing, or vice versa the doors with specific attributes can be seen visually on the drawing in reference to the whole project.

Different team members will use different tables (illustrated in Figure 4) based on the information they are reporting or the information they need to have access to. For example the Field Manager will have read only or view only access to the tables "Contract Documents" as they will only access this page to retrieve information related to the construction elements. However, the "Work Progress" table is accessible to the Field Manager as read-write, as they will need to add to this table and update the work progress onsite. The "Pay Application" table is a table accessible to the Project Manager as read-write, as they are entitled to modify the content of this table. Access and modification of the tables and their contents is governed by preset rules for the construction team, based on their duties and their roles within the team.

The proposed model provides the different teams involved in the construction process with access to up to date reliable information, and minimizes the effort required to maintain accurate up to date contract documents, as the change is reflected in the tables as soon as it has been acknowledged and approved. All the participants in the construction process will have access to this information eliminating the risk that any of the participants failed to be notified in time. Changes will be reflected in an additional data table, which will be linked to the construction element ID. Any approved new changes will be added to the contract documents.

Databases can include heterogeneous types of information that are related to the construction element, and they provide a flexible solution to manage changes as they occur within the construction phase of the project. This database is stored on a project server accessed through a project network, thus ensuring that no duplication and redundancy of the information is occupying unnecessary storage space.

THE ADVANTAGES OF THE PROPOSED MODEL

The information generated during the construction phase is organized and structured in tabular format that can be used as reliable historical data for future projects to improve design, predict changes, improve productivity, or even generate a set of guidelines for future schedule or estimates that may create a competitive advantage to the construction team in avoiding future problem in future projects. Unlike the actual common practice where the different team members involved in the construction process, generate information using paper based format, the database will allow easy manipulation of the data to generate more information.

The suggested model will save the construction teams a lot of time spent on coordination, where the different teams involved in the construction process meet constantly in order to share and update the information related to the work progress. The suggested model will allow the different teams to communicate with each other through the input of the data in the shared database. Consequently, this will save the other teams the effort to update their own records, as it is the custom in actual practices. The suggested model will cut the redundancy of activities related to updating the construction records, and documenting the work progress. In addition to saving time, the suggested approach will help eliminate the errors that results from the failure to update the construction documents, or even misinterpretation of the communicated data among the different teams.

The model will provide the construction teams at the executive level at the first stages of the project with reliable historical data that is generated from the ongoing construction operations at the construction phase. The conceptual estimate at the initial phase of the project will be entered in a format that will be consistent with the one used at the construction phase. The data generated at the early levels of the project is integrated with the information related in the phases to follow. At the second stage of the project, when a different team is mobilized to the site, they will have access to the information generated by the construction team from the initial phase. This will enable them to use this information and develop detailed breakdowns of the activities assigned to the different subcontractors. This is linked to the planned schedule on the jobsite.

At the construction stage the construction team will be able to enter the project information and compare it with the provided model generated in the previous phases. The executive members of the construction team can measure and compare the productivity of onsite construction team versus the historical data provided from the previous projects. The deviation from the planned can then be easily evaluated and used to assess the performance of the onsite construction team and measure their productivity and overall success to fulfill their assigned tasks. These measures can be used to modify the database to correct assumptions used on future projects.

CONCLUSION

The suggested “visual information access and management model for life cycle project management” will provide a simplified solution for a complex problem. It is intended to integrate the information among the different construction team members and the different parties involved in the construction phase. If implemented within the setting of a construction project, it is expected to link the information generated in the construction phase to create smart data that can be used as reliable historical data for use as a reference for future projects. The model will help the construction team save time and effort locating the scope of work. In addition, less time will be spent on communication of information with the other parties involved in the construction process, allowing the construction team to focus more on the construction activities, instead of tedious activities in order to report, document and communicate information with the rest of the team members. The suggested model is intended to provide more information to the construction team without a loss of productivity as it does not require the different construction team members to adopt new technologies or to learn new industry practices.

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