REVIEW OF DESIGN MANAGEMENT PROCESSES AND EFFICACY OF BUILDING INFORMATION MODELLING (BIM) WITH A VIEW TO EVOLVE A NEW CONCEPTUAL FRAMEWORK OF INTEGRATED APPROACH FOR THE AEC INDUSTRY

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Availability of the diverse tools and data used during the design process necessitates the selection and use of a design environment with integrated design management capabilities.

Once establishing design as a process, it is discussed in relation with the attributes of integrated planning and control.

The authors then discuss design management with respect to BIM and compare it with other conventional design management strategies. They review current thinking and practices in BIM, and then propose a generalized model for design management in the AEC industry.

Special emphasis is laid on the efficiency of BIM and how it can be adapted effectively.

The new conceptual framework of design management in BIM is presented while simultaneously studying this framework with reference to existing design management theories.

Keywords: Design management, Building information modeling (BIM), Design collaboration and communication.

1. DESIGN

The International Council Societies of Industrial Design (ICSID) elaborates design as:

Aim: Design is a creative activity whose aim is to establish the multifaceted qualities of objects, processes, services, and their systems in whole life cycles. Therefore, design is the central factor of innovative humanization of technologies and the crucial factor of cultural and economic exchange.

Tasks: Design seeks to discover and assess structural, organizational, functional, expressive, and economic relationships with the task of:

- Enhancing global sustainability and environmental protection
- Giving benefits and freedom to the entire human community
- Supporting cultural diversity despite the globalization of the world
- Giving products, services, and systems, those forms that are expressive of and coherent with, their proper complexity

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Design can be interpreted in two ways:

- It can refer to either an activity (the design process) or
- The outcome of that activity or process (a plan or form).

A designer functions as a coordinator, and takes into account all of the components of the project. Therefore, the traditionally held tenet that all designs are unique and therefore cannot be planned or managed is outdated and no longer valid. Design is a process, which if correctly understood and represented can be largely repeated from one project to the next and therefore can be defined, measured and improved upon.

1.1. Design Processes

Design processes can be conceived in at least three different ways:

- As a process of converting inputs to outputs,
- As a flow of materials and information through time and space, and
- As a process of generating value for customers

The design process has four essential characteristics-the 4 Cs (like the 4 Ps of marketing) i.e. creativity, complexity, compromise and choice. It thus becomes imperative that the design process be essentially experimental in nature. Holt (1990) identifies three types of design processes:

- The *analytical_design_process*, used when there is little uncertainty about the alternatives, and the outcome is only a modification of something already existing.
- The *iterative design process*, which is best for radical improvements and adopted innovations.
- The *visionary design* process, in which the problem cannot be defined precisely and is, perhaps, vague at best.

All these design processes have a unique character. The process, like any other, can be sub-divided into phases. The final goal of every phase is to create a visual output. Because of visualization, all of the steps in the chain of innovation become simulation. This accelerates process-oriented fabrication [Freund *et al*., 1997]. Once the innovation takes shape, the physical symbols provide a powerful aid in the communication process. The images pass from two-dimensional drawings to forms that resemble the final product more and more, such as nonfunctional and functional models. These models serve as visible and accessible symbols of the final product; they help to unify the design team and reveal any possible technical flaws.

Figure 1 elucidates the different phases during a design process. As explained above, all of these phases can be directly treated as visual outputs of varying typology based on the phase of work. Thus the above flow chart results in visual outputs in phases in an AEC industry as shown in Figure 2.

1.2. Diverse functions and tools

There is a necessity of managing the interactions between the many partner functions (Figure 3) and their integration into design decisions, even if the respective importance of each function varies according to the phase in the creative process.

In deciding on the most appropriate structure, the design manager has many issues to consider:

- *Flexibility versus consistency*: The design manager must invent processes that provide consistency or a certain amount of rigidity in terms of how things are done and flexibility in terms of creative thinking.
- *Autonomy versus control*: Manager must choose in terms of where the lines of discretion are drawn between senior and relatively junior members.
- *Centralization versus decentralization*: Who is allowed to make which decisions?

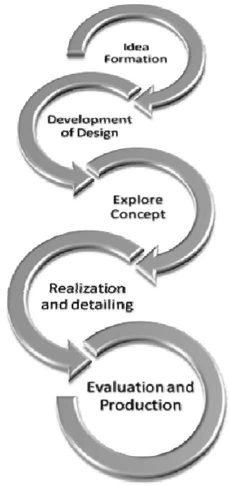

Figure 1. The Design Process.

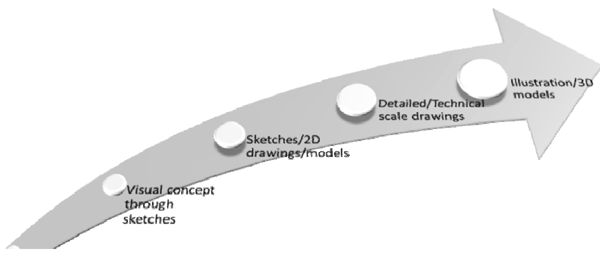

Figure 2. A typical visual output of a Design.

2. DESIGN MANAGEMENT

In practice, design management controls two areas:

- The administration of relationships
- The administration of processes

Design management has to learn to see the underlying variables that influence long-term behavior and actions and apply them to product ideas, technology, and management know-how.

2.1. Design Management in AEC industry

The Architectural/Engineering/Construction (AEC) industry is most definitely the largest industry in the world. Successful completion of building projects requires collaboration of numerous multidisciplinary and sometimes geographically separated team members. Thus, the large amount of inter-disciplinary activities calls not only for strong technical skills, but also efficient management skills at the top of the pyramid. To ensure efficient management and utilization of human and material resources, an efficient design management tool is mandatory.

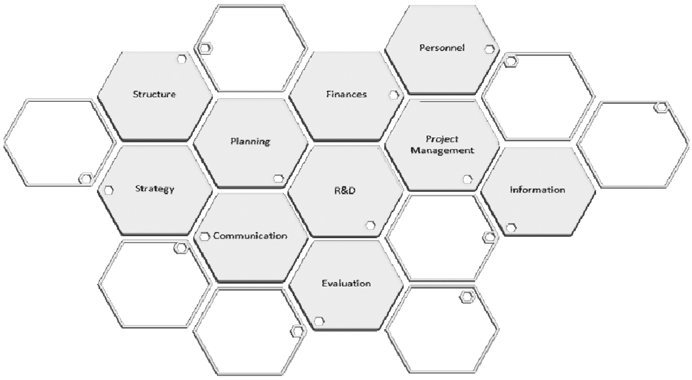

Figure 3. Diversity of Design Management.

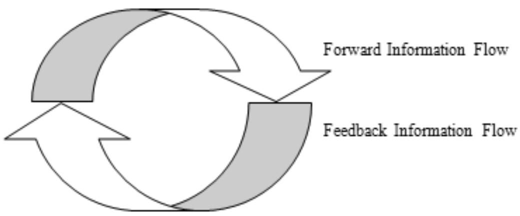

Figure 4. The To and Fro Approach.

2.2. Conventional Design Management Systems

To resolve these issues some design management techniques have been developed in the past based on different concepts and have been used with varying degrees of success.

The To and Fro Approach: The current Construction management approach is based on a to and fro approach (Figure 4), which is explained below:

- a forward information flow to drive process behavior and
- a feedback information flow for monitoring purposes

The feedback flow is typically used to adjust the forward information flow in order to meet the overall expected project performance.

In the AEC industry, the forward information flow corresponds to the flow of information resulting from design, planning and management activities, and the feedback flow results from construction activities, monitoring and implementation.

2.2.1. Project Management

The conventional view on design management has essentially been the same as in Project Management (Figure 5) which is based on the assumption that the work to be done can be divided into modules and managed as if those modules were independent. Work breakdown structures are driven by scoping and budget concerns and have the objectives of insuring that all the work scope is included in one of the modules. This division into modules is necessary in order to allocate responsibility to internal or external work centers, which can subsequently be controlled against scope, budget, and schedule commitments. This is fundamentally a contracting mentality, which facilitates the management of contracts rather than the management of (design) production.

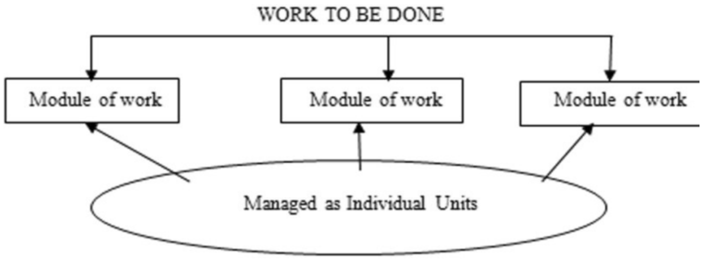

Figure 5. Project Management.

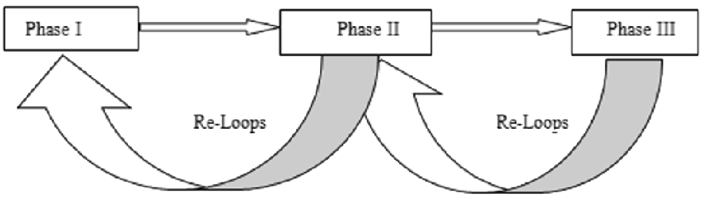

Figure 6. Concurrent Engineering.

2.2.2. Concurrent Engineering

Concurrent engineering (CE) is a conceptualization of the product development process found in the world of product design and manufacturing. As it entered the AEC industry it became sequential rather than concurrent. The architect develops a concept and hands it over to the structural engineer. The Engineer may or may not be able to engineer the facility as conceived by the architect, so re-loops and revisions are common (Figure 6).

3. THE NEED FOR AN INTEGRATED APPROACH

Generally, the management of design and engineering is felt to be problematic in AEC projects. The most significant causes of design problems are [Coles (1990)]

- Poor briefing and communication,
- Inadequacies in the technical knowledge of designers and
- A lack of confidence in preplanning for design work.

In another study on technical design of buildings it was found that the most frequent causes for severe deviations during design were

- Deficient planning and/osr resource allocation,
- Deficient or missing input information and changes.

Similarly, Josephson found that when measured by cost, design-caused defects are the biggest category. From design caused defects, those originating from lack of coordination between disciplines are the largest category.

Common consequences include slow approvals from clients, late appointments of consultants, and inadequate time to complete design documents carefully and hence an overall failure of the design planning and management as such. For the collaborators, all change is felt like a loss. So, the company has to make sure the change is perceived as necessary and not imposed, to encourage training while ensuring continuity, and to treat the problem of the resistance to change in order to make sure the new reality is accepted.

Availability of the diverse tools and data used during the design and construction processes necessitates the selection and use of a design environment with integrated design management capabilities. The traditionally compartmentalized Architecture/Engineering/Construction (AEC) industry has been gradually moving towards more collaborative approaches to meet the seemingly never ending demands for delivering projects of higher quality in shorter times and at a lower costs.

The use of Building Information Modeling (BIM) as a tool may help in achieving the team's project goals; the BIM itself, however, should not be the final goal—it really is a tool.

4. BUILDING INFORMATION MODELLING

Building information modeling is, essentially, the intersection of two critical ideas:

- Keeping critical design information in digital form makes it easier to update and share and more valuable to the firms creating and using it.
- Creating real-time, consistent relationships between digital design data-with innovative parametric building modeling technology-can save significant amounts of time and money and increase project productivity and quality.

The goal is not simply having a BIM, but it is the project understanding generated through the creation of the BIM, and the benefits of the use of the information that is available through the BIM.

4.1. BIM in Practice

Building information modeling simulates the construction project in a virtual environment. A simulation has the advantage of taking place in a computer through the use of a software package. Virtual building implies that it is possible to practice construction, to experiment, and to make adjustments in the project before it is actualized. For each of the three major phases in the building lifecycle-design, construction, and management-building information modeling offers access to the following critical information:

- In the design phase-design, schedule, and budget information
- In the construction phase-quality, schedule, and cost information
- In the management phase-performance, utilization, and financial information

4.2. BIM as a Contemporary Design Management Tool

The process of building design and documentation is iterative. The understanding of a design problem develops during the design process. In addition to the refinements typical to any design process, a new insight into the design problem may lead the design team to discover that the solution could be quite different, and possibly better. At that point iteration occurs that may reconsider earlier assumptions. Managing this iterative change is an inherent part of BIM solutions as BIM is essentially management of relationships within the data.

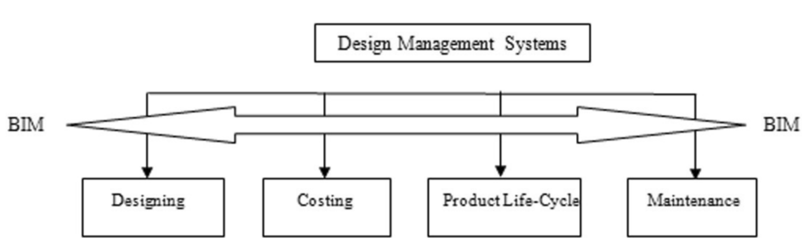

Figure 7. Scope of BIM.

The BIM process is a planning and managing process (Figure 7) for building construction projects, and it is thus important for this process itself to be planned and managed carefully.

To generate a list of processes (steps) necessary to produce the deliverables for the BIM, the overall BIM processes can be broken down into groups as follows:

- Planning the project
- Communicating the project
- Coordinating the project.
- Updating the project
- Information feedback loop
- Tracking the project
- Delivering the BIM

Conceptualizing the design process as a flow of information in a virtual environment allows coordination of interdependent flows and the integration of design with supply and site construction. Thus follows that BIM acts an efficient tool in aiding all existing design management systems to integrate and collaborate the work as required.

5. BIM AS A GENERIC SYNERGISTIC TOOL TO ACHIEVE VERTICAL INTEGRATION

Traditionally, design and project management is organized under near-independent but interconnected functions. This horizontal partitioning of projects (Figure 8) based on functional domains has often

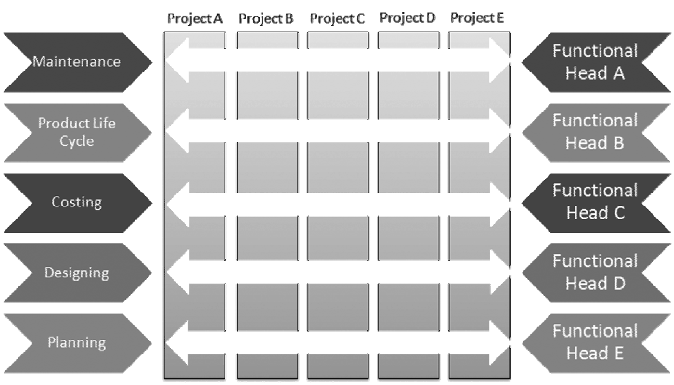

Figure 8. Tradition Approach to Design Management Horizontally Partitioned.

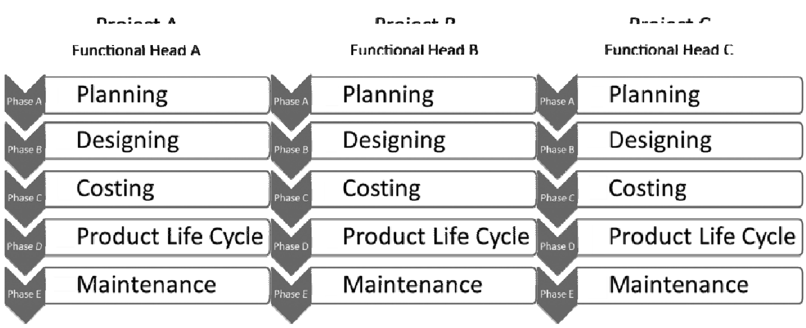

Figure 9. Integrated approach favoring vertical integration.

resulted in lack of coordination and synergy. The modern management practices are increasingly seeking to vertical integration of these processes /functions in order to achieve a seamless and collaborated approach wherein a project management team cutting across functional processes and expertise seek to achieve efficiency and synergy of a well-oiled relay team passing baton to one another under the overall supervision of a single coach. In our endeavor to fructify this approach, the BIM has a major role to play.

Figure 8 elucidates how conventionally parameters and boundaries were rigidly defined and work moved in a horizontal sequential manner. Each phase in a project was handled by individual functional heads under the presumption that all phases were in reality independent of one another.

The Figure 9 explains how integration has now become vertically oriented and instead of individual functional heads works under a single project head who oversees the entire process in tandem. It becomes imperative that BIM becomes a major tool to make the integration possible.

5.1. Implications of the Vertical Integrated Approach

Many of the implications of this approach are direct ones like an immediate change in organizational structure and hierarchy, although the actual implications are the indirect ones which include the necessity for collaboration and the resulting better project understanding and the reduction of project risk. These so-called next generation collaborative workspaces will be achieved through enhanced human communication, innovative visualization, knowledge support, natural interaction and above all, a reformed educational system which aims at students trained into more competitive, productive, and creative collaboration-driven work patterns.

6. CONCLUSION

The framework analyzed in this paper is a preliminary outline for something that ought to be developed into a precise tool seeking increased efficacy of the contemporary design industry through a symbiotic relationship between the design management systems and BIM through “vertical integration”. It is based upon the ideas collected in this study but there is a need to define how the knowledge obtained from real projects should be defined, particularly the economic factors in relation with carrying out the organizational changes, which could convince new users of the said approach. Further research may be carried out to establish a benchmark for costs and benefits associated with its implementation so that their value over time can be measured.

REFERENCES

1. Coles, E.J. (1990). Design Management: A study of practice in the building industry. The Chartered Institute of Building, Occasional Paper No. 40, p. 32.
2. Cooper, K.G. (1993). “The Rework Cycle: Why Projects Are Mismanaged.” PM Network, February, pp. 5–7.
3. Anumba, C. and Evbuomwan, N. (eds.)(1997). Concurrent Engineering in Construction CEC’97. Proc. 1st International Conference. London, 3–4 July, The Institution of Structural Engineers, London, p. 337.
4. Walsh, Vivien, 1995, “The Evaluation of Design,” International Journal of Technology Management, vol.10, nos. 4/5/6, pp. 489–509.
5. Walsh, Vivien, Robin Roy, Margaret Bruce, and Stephen Potter, 1992, Winning by Design, Basil Blackwell.
6. Creating value in engineering projects. (1996). ICE design and practice guide. 64 pp. Thomas Telford, London.
7. Sriram, R.D. (1998). “Information Technology for Engineering Design.” ASCE, *Journal of Computing in Civil Engineering*, 12(3), pp. 123–125.
8. Walker, A. (1996). Project Management in Construction. 3rd ed. Blackwell Science, Oxford.
9. Freund, Bruno, *et al.*, 1997, “Impact of Information Technologies on Manufacturing,” International Journal of Technology Management, vol. 13, no. 3, pp. 215–28.
10. Ballard and Koskela. “On the agenda of Design management research”.
11. Austin, Baldwin, Li and Waskett, “Analytical Design Planning Technique: A model of the detailed building design process”.
12. Mena, Crawford, Chevez, and Froese “Building information modelling demystified: Does it make business sense to adopt bim?” International Conference on Information Technology in Construction Santiago, Chile 2008.

13. Ted Sive "White Paper BIM (Building Information Modeling): A Marketing Primer and Call to Action".
14. Popov, Juocevicius, Migilinskas, Ustinovichius and Mikalauskas "The use of a virtual building design and construction model for developing an effective project concept in 5D environment." Automation in Construction 19, (2010) pp. 357–367.
15. Colin Gray and Will Hughes "Building Design Management", Elseiver, 2001.
16. Willem Kymmell "Building Information Modeling Planning and Managing Construction Projects with 4D CAD and Simulations", McGraw-Hill, 2008.
17. Brigitte Borja De Mozota "Design management: using design to build brand value and corporate innovation" Allworth Press 2003.
18. Andersen, Nycyk, Jolly and Radcliffe "Design management in a construction company".
19. Jones, Christopher, 1992, Design Methods,Wiley & Sons, (first edition, 1970).