

# DESIGN MANAGEMENT IN A CONSTRUCTION COMPANY

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## Abstract

Design Management is an increasingly important function in the construction industry. Design management is being done by construction companies because of the failure of other existing systems to achieve proper integration of the design and construction processes.

Initial results from a three-year empirical study of the practice of design management in an international construction company have been compared to conceptions devised from literature in order to describe design management practices. The project will include a detailed description of design management practices in a construction company, which will provide information that can be used as a foundation for formal training programs involving engineering design management.

Three conceptions of design management: design management as “integrators of design and construction”; design management as “managers”; and design management as “meta designers” were compared to case studies conducted on a variety of projects. Further case studies are planned to determine the role of design management in the early project stages.

Early results indicate that design management has several roles which involve different personnel within the company at different project stages. In early stages before tender submission the hypothesis is that design management personnel are best conceived as managers of design. Another case study will be done to determine this. Once a project was acquired then the design management personnel were better conceived as “meta designers” rather than as “managers”. The design management personnel also dealt with issues arising from the integration of design and construction. Detailed analysis using data variables will be done to determine which conception at which project stage best represents the role of design management.

## Background

Design Management is an increasingly important function in the construction industry. Projects are becoming more complex and global and new contractual arrangements, which require alliances and partnerships between designers and constructors are increasingly used<sup>1-3</sup>. Gray<sup>2</sup> suggests that design management is being done by construction companies because of the failure of other existing systems to achieve proper integration of the design and construction processes.

From the 1900's to the 1980's preferred method of project delivery was design-bid-build and personnel in the construction industry were trained with this assumption in mind<sup>4,7</sup>. Professional architects and engineers distanced themselves from construction and shunned design and build projects<sup>4,5</sup>. During this time architects and the different engineering disciplines became more specialized<sup>8</sup>. They began to be educated separately in universities and their knowledge of construction declined<sup>4,5</sup>. In complex one-off projects most of the design detail was traditionally completed before creating an estimate and bidding to construct the project<sup>6</sup>.

From the 1980's the construction industry has been increasingly pressured to participate in new project acquisition processes. The industry must now take on and estimate projects in which the design is not yet complete<sup>1,9</sup>. This is being done in order to reduce the total project time for several reasons: 1) because design can be completed while construction is being undertaken and thus potentially be completed faster; 2) to increase the constructor's accountability for design; and 3) to generate a less adversarial working environment. That ideally means a collaborative or integrated approach be undertaken by design and construction<sup>3</sup>; or a concurrent approach where design is done just in time for procurement and construction<sup>9-11</sup>.

These highly complex, multi-stakeholder projects change fundamentally the dynamics of the relationship between design and construction and the management of activities between the two<sup>1,9,12</sup>. In earlier times when design was completed before construction, design management was largely about the management of designers' activities, influences and outputs in an architectural or engineering consultancy<sup>13</sup>. This was a relatively contained activity that focused on the production of design documents for the client. With the rise of new contractual arrangements, design management now involves a much more complex set of relationships between the client and specialists from design consultancies, vendors, manufacturers and constructors. Correspondingly the functions of design management are much broader and much less well defined. It is this conception of design management that the construction companies, rather than design consultancies, are taking responsibility for in increasing numbers.

This role seems similar to the role of the chief engineer or architect during the 1800's<sup>4,5</sup>. During the 1800's architects and engineers were responsible for the design and construction of complex construction projects<sup>4,5</sup>. Due to the disparity in the amount of time, complexity, stakeholders, capital distribution, allowed risk and amount of design and construction integration required, roles in the 21<sup>st</sup> century are not the same as in the 1800's. A detailed account of the functions of design management is required if educational institutions and construction companies wish to provide adequate education for them into the future.

## Theory

There has been very little empirical research on design management, even that undertaken in traditional design consultancies, and almost nothing in relation to design management in complex one-off projects involving fast tracking and new types of contractual relationships.

Some insights into the roles and responsibilities of design management in complex one-off projects in the construction industry were derived by extrapolation from published case studies of engineering designers in practice and of design management in other engineering contexts, in particular the manufacturing industry. These studies and research done to date lead to the development of three different conceptions of design management in the

construction industry; 1) design management as “integrators of design and construction”; 2) design management as “managers”; and 3) design management as “meta designers”. Depending if the tasks prevalent in these concepts are observed or not it will be possible to see which job functions design management is meant to fulfil and thus which concept is most applicable to design management in the construction industry.

#### Design Management as Integrators of Design and Construction

Design management in the construction industry has been conceptualised as a role for integrating design and construction with the term “integrators of design and construction”. If the serial design-bid-build mind set is being applied in design and construction projects then there will be impediments to the integration of design and construction in these projects.

Constructors would not expect to interact with designers and they would not expect designers to have input into their processes. People would try to stick with original estimates as they have traditionally done, because these estimates were once based on detailed design. As they are now based on an ambiguous concept people would be disappointed when comparing final project costs with these estimates<sup>14</sup>. In design-bid-build the design and design costs would be fixed before construction began, but in design and construct the design goes through iterative changes whilst construction is being conducted. Construction's traditional way of working would thus have limited flexibility to changing design and design costs. Construction personnel would traditionally wait for the final design to be done before giving their input and thus make last minute design changes. Where this once worked, because design rather than construction were responsible, these last minute changes in design and construction projects not only cause construction delays, but the design and construction venture takes responsibility for these delays and the design rework. Document deficiency once viewed as design deficiency<sup>15, 16</sup> may not apply in this integrated environment if design and construction use different methods of conveying the design intent.

As design managers are utilised by the construction industry in projects where they are responsible for design and construction then one would expect them to take on functions required to better integrate design and construction and as such overcome some of the above issues. Design managers may integrate the design and construction processes and as such may provide training in new project delivery methods. They may ensure timely interaction between designers and constructors including preparing them for ambiguity; last minute information, and changes. Design managers may devise new methods which compensate for unavailable design information, for example flexible estimating, scheduling and construction methods. They would need to ensure the construction is not deficient no matter how the design is delivered. It would be their responsibility to solve design and construction problems by participation rather than arbitration<sup>12</sup>. Things such as making allowances for design trials during construction may be permitted by this new relationship.

#### Design Management as Managers

A conception taken in this project and the conventional conception taken in literature is that design management is a division of management<sup>17</sup>. Design management as a division of project management; design management as managing design; and design management as task management, flow management and value management were conceived under this category.

### Design Management as a Division of Project Management

If design management were a division of construction or project management then one would expect related literature on project management to give insights into the task of design management. Such tasks and responsibilities are demonstrated by Gray & Hughes<sup>18</sup> as follows: tactics for developing a project culture; defining the tasks; managing information production; evaluation of information; and planning, monitoring and control.

### Design Management as Managing Design

Design management in the manufacturing industry is considered as a process of managing design and the design process. Hales<sup>13</sup> suggests that successful management of the design process boils down to the effective handling of three issues: 1) activities of the design team, 2) output from the design team and 3) influences on the design team. Cooper & Press<sup>19</sup> suggest design management are responsible for 1) developing a matrix for managing design, because it involves a number of organisational levels and activities; 2) planning design, which involves including design in organisational goals, strategies and policies for design, and putting process in place for using design; 3) organising for design, which means having the right structure, choosing the right teams, using training and development programs and investing in design; 4) implementing and monitoring design, which involves implementing and monitoring design programmes and projects; and 4) evaluating design including evaluating the management of design and design projects. Along the same lines Cross<sup>20</sup> suggests that design management is responsible for design strategies and tactics as well as product development, planning and innovation. They suppose that design management should have intimate knowledge of the design process in order to manage it and are expected to know what designers do. They are thus expected to manage both designers and the design process.

### Design Management as Task, Flow and Value Management

Another conception is that design management can be viewed in three different ways 1) as a process of converting inputs into outputs (Task management), 2) as a flow of materials and information through time and space (Flow management) and 3) as a process of generating value for customers (Value management)<sup>21</sup>. The methods and practices of design management suggested in Ballard<sup>17</sup> are for the conversion view: work breakdown structure; critical path method; and organizational responsibility chart; for the flow view: rapid reduction of uncertainty; team approach; tool integration; and partnering; and for the value generation view: rigorous requirement analysis; systematized management of flow down of requirements and optimisation.

### Design Management as Meta Designers

Initial observations of design management revealed tasks being done that did not fall under the “management” conception and were perhaps in the domain of designers on smaller design projects. Dorst<sup>22</sup> suggests that when projects become large major design projects the kind of comprehensive overview that designers need to possess in smaller projects inevitably gets lost.

Meta designers, which are used in the IT industry design things so that the users become the designers and as such they design the design system rather than design a system. That then incorporates users as co-developers or co-designers<sup>23</sup>. The definition used here is that “meta

design” is about incorporating others such as stakeholders, consultancies and sub-contractors as co-developers or co-designers, designing the design system and doing tasks which were perhaps in the domain of designers on smaller projects.

The following functions of designers from Dorst<sup>22</sup> are examples of tasks that designers have in smaller projects, which design management in larger projects may take on in order to maintain a comprehensive overview: integration of the various demands of the project’s stakeholders; interaction with groups of people that have different ways of looking at the design problem; determining design strategies; balancing design risk; and taking into account the larger whole.

## Research Method

The tasks and practices of design management have been examined by gathering empirical data in a series of case studies of design management in complex one-off construction projects in industry. The research method is based on case study research<sup>24</sup>. The method used for case study data collection and analysis is depicted in figure 1. This figure is similar to that described for data convergence by Yin<sup>24</sup>. Each of the key concepts in case study research: document analysis; observation; participant observation; interviews; surveys; and literature reviews, as shown in figure 1, has been achieved by analysing the direct inputs in figure 1 from the different case studies as described in section 5.1. Several case studies on various complex one-off engineering projects are being done in order to converge the data and to determine the domain in which the results pertain to design management in the construction industry. Literature reviews have complemented this and will also be used to determine if the results pertain to design management outside the construction industry.

In order to analyse the information items such as key event logs, grouping of data with suitable data variables, journals, summaries etc. as shown in direct outputs figure 1 were devised. Each output and ongoing analysis has been an influence on the next set of information gathered. This is done in order to obtain the relevant data required within the 3 year study period. Case studies thus far have been analysed with methods including organizing data into key performance indicators and comparing them in order to see data patterns and organizing data in relevant groups determined by the main issues discussed. Surveys questions have been ordered and ranked according to number of responses and the questions grouped according to economic context, general job function, division within company and project stage. All results have been discussed at meetings with university researchers and with design managers within the company for verification. Items such as concept diagrams, data patterns and statistics have been devised from such analysis.

These early results are based on analysis done thus far. To date each case study has been analysed separately and qualitative comparisons made between the case studies. It is envisioned that at the end of the data collection period the case studies will be compared with suitable data variables which will positively determine which of the conceptions is most appropriate for design management. This will form the basis of a description of design management which includes the tasks and practices of design management and the influences and results of these tasks and practices.

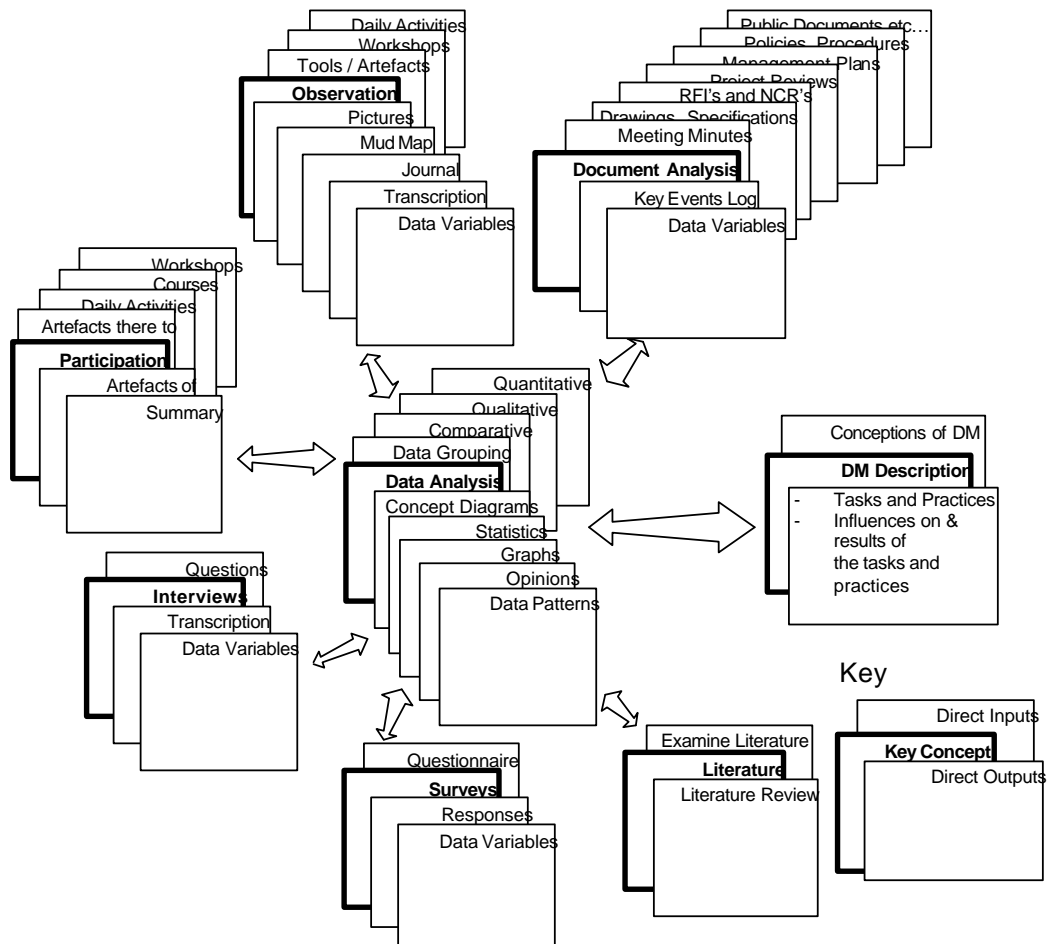


Figure 1 Method used for data collection and analysis

### Case Studies

Three case studies have been completed, another 2 are underway and a further case study is planned in the future. Two case studies have been done on completed projects. A case study was done comparing two hospital projects in the building sector of the construction industry, and on a dam project in the civil sector of the construction industry. Case studies have been done on projects in progress during the case study. One has been done on a large multi million dollar tank project combining the civil and process sectors of the construction industry, another case study is being done on a tunnel project in the civil sector of the construction industry and a third is being done on the development of a process plant in the minerals industry. In case studies on completed projects document analysis, interviews with project participants and literature was reviewed in order to determine the design management functions. In case studies on projects in progress document analysis, observation, participation, interviews with design management throughout the different stages of the project, and literature was reviewed in order to determine the design management functions. A future case study is planned on the early stages of a project. Document analysis, observation, participation, interviews with design management and literature reviews are also planned for this case study.

## Surveys

A survey was distributed to 30 people involved with design management within the construction company. 32 activities were surveyed in order to find out what activities design management currently manage, participate in or are not involved in; what they would like to manage, participate in, or be not involved in; what are considered time consuming activities and what are considered important activities. The functions of design management from these surveys are to be compared to the case studies in order to confirm or dispute the survey results. Another survey combined with a social network analysis is underway, which will also be used to help determine design managements role.

## Design Management Roles

In the case studies different people fulfilled the role of design management. People with various titles often undertook the tasks that design management were responsible for in the three different conceptions and that which was cited in company documents. This suggested that meta design, management of design and integration of design and construction were all required in large projects. The titles of people who performed the functions of design management and the core tasks they perform is described in order to explain, who was conceptualised as a “meta designer”, who was conceptualised as a “manager” and who was conceptualised as an “integrator of design and construction”.

Before a construction company put in a bid or tender design management determined who was to do the design for tender. This involved selecting the design team, establishing contractual relationships with the design team, drawing up a schedule for design, financial and estimating reviews, tender submission and establishing facilities in order to do this. Their primary role was to determine if the design was going to be “a red left handed one” or an “orange right handed one”. That is they determined the strategy for design; and did organising for design. Results thus far indicate that this role resembles the conception of design management as managing design.

Once the company had received the contract for a project they normally required a person to set up the way design management would work later on in the project. This included setting up systems, which enabled the various stakeholders to submit critique, change and approve parts of the design. This person established relationships with the various stakeholders involved and determined who and what was required in order to best manage the input from these stakeholders. These people weren't directly responsible for the design or the design team; and they didn't have many design sub-ordinates to manage. Results thus far indicate that their primary role resembles that of the “meta designer” concept.

As the design began to progress design management personnel were resourced or consulted according to demand. These personnel consisted of design directors, design managers, senior design engineers or senior architects, design-construction coordinators, design integrity managers and engineering managers. They were often used to do the tasks that designers do on smaller projects, but which inevitably get lost on larger projects. Tasks were done such as: checking that the overall design conformed to the relevant standards; investigating various design options; making preliminary judgements of design options, ensuring that design stayed on track, and balancing design risk. Results thus far indicate that the role of design management at this stage resembles the “meta designer” concept because these people spent most of their time incorporating stakeholders as co-designers and doing tasks that designers would do on smaller projects such as investigating various design options. However the

design manager as a division of project management concept hasn't been ruled out because they also partook in activities such as planning, monitoring and control and they calculated document control and design progress metrics.

When there weren't all these personnel the remaining design management personnel took on the roles of the other team members. Towards the finalisation of the design work only one person, either a senior design engineer, senior architect or design manager was left to deal with the remaining design management issues. Case studies thus far indicate that design management personnel are taken off the project before design finalization and the remaining design management issues left to the construction team and design consultancy.

The issues arising from the integrating design and construction conception were also apparent during the case studies and work was done in order to overcome these issues. Design management personnel did ensure that design and construction had ample contact. They dealt with issues occurring between design and construction, such as when design clarifications needed to be made. They were faced with issues arising from the design-bid-build way of working, such as constructors making last minute design changes and systems requiring completed design information. Further analysis is required to determine if this is a primary or secondary role, if it is a shared role or if this conception fits into "meta designer" considering that design and construction are stakeholders.

#### Design Management as Integrators of Design and Construction

Design management personnel were observed dealing with many of the issues required to integrate design and construction. Overcoming or moderating the issues between design and construction was seen as a necessary role in the construction industry. When these issues were not addressed properly confusion over construction techniques arose, design intent was lost in the final constructed product, unnecessary delays took place and poor project satisfaction was observed. Incorporating design and construction as co-developers or co-designers is one way in which integration of design and construction is dealt with.

#### Design Management as Managers

Many of the conceptualised tasks that were done as described in the conception design management as a division of project management, were in the context of design management personnel ensuring stakeholders including constructions input into the design. Some of the tasks were the responsibility of project management or project controls.

Some of the tasks in the conception of design management as managers were required before tender submission in order to establish the future conditions for design. Further information is required in order to determine if this concept adequately describes design management in this early stage of a project.

Early results indicate that the conception of design management as task, flow and value management<sup>21</sup> does not adequately describe the practical role of design management in the construction company, because the concepts, main principles, methods and practices in each of the views did not represent design managements main functions.

#### Design Management as Meta Designers

Once a project was given to the company after the tender stage design management personnel were observed designing and maintaining a system, which incorporated stakeholders as co-

developers or co-designers. They were also observed doing tasks which designers are responsible for in smaller projects that inevitably get lost in larger projects.

Two main functions of design management personnel cited in company documents was ensuring stakeholders understood design developments or design changes and maintaining the design intent. Utilizing stakeholders as co-developers or co-designers ensured that they were up to date with the design developments and that the design intent was maintained. When the tasks of incorporating stakeholders as co-developers or co-designers were neglected a resultant delay or hold-up became apparent. Such delays were for example document delays because designers didn't understand stakeholder inquiries. Technical design knowledge, design progress and the knowledge of different stakeholder requirements were requested of design management at many different meetings.

### Conclusion

Early results indicate that design management has several roles which involve different personnel within the company according to the stage the project is in. In early stages before tender submission design management personnel had a different conceptual role to that once a project was acquired. After a project was acquired case studies indicated that design management were better conceived as "meta designers" rather than as "managers". Design management personnel also dealt with issues arising from the design-bid-build mind set being applied in design and construction projects. Further analysis and case studies are being conducted to substantiate these indications. This information can be used as a foundation for formal training programs involving engineering design management. For example if results prevail their education should include the functions that a manager of design and a "meta designer" needs to perform, explanation of the different roles in the different project stages and further research and training in integrated design and construction techniques.

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