5. Conclusion and Recommendations

5.1 Introduction

The study has assessed the root causes of the design management problems on the Medupi structural steel and evaluated design management tools and methods which have previously been developed. This was done in reference to the objectives of the study as stated in section 1.5. These were to;

- To establish the root cause of the design changes on the case study.
- To intensively analyse Design Management techniques.
- To select the most appropriate for Global Collaborative projects.

On the basis of the theoretical discussions in Chapter 2, and the empirical findings and discussions in Chapter 4, a summary of the findings, the main conclusions and the recommendations are presented in this section.

5.2 Summary

This section provides a summary of the study. Initially, it gives a general overview of what is contained in each chapter. The section then points out and relates the major themes that emerged from the literature review and empirical findings. The aim of the discussion of these themes is to find ways in which the weaknesses that emerged from the study can be addressed. In other words, the objective is to determine which design management tool/method can be utilized on Global Collaborative projects such as Medupi.

Chapter 1 of the study set the background of the whole study while Chapter 2 reviewed international literature on design management. Design management tools, methods, models and processes were evaluated in order to determine criteria of requirements for effectively managing changes on global collaborative projects. Chapter 3 provided the research design of the study, while Chapter 4 discussed and analyzed the research findings.

The findings given in Chapter 2 were the basis for the empirical research which uses a qualitative approach as described in Chapter 3. The breakdown of the design management tools/methods emanated from the information contained in Chapter 2.

From the literature review, it is apparent that design management is an area that needs further research. It is clear that no tool has been developed specifically for global collaborative projects. The approach therefore was to select a design management tool/methods, from those previously developed, which is more likely to work on Medupi and other similar projects to address the problems experienced.
A description of how, as part of the Analytical Design Planning Technique (ADePT), the output from a design process model is used to produce a dependency structure matrix (DSM) via a schedule of information requirements is presented in Chapter 2. A prototype dependency structure matrix (DSM) tool, the algorithmic matrix manipulation program (AMMP), has been developed that suits the requirements of building design analysis. The tool schedules tasks in the design process on the basis of their information requirements, identifies areas of iterative work within the process and allows the effectiveness of eliminating the need for some information estimates by over-designing to be examined. The output is used to produce a design program of the optimized design process.

The algorithmic matrix manipulation program (AMMP) program has been verified and tested by successfully representing the design process of a number of building projects within an acceptable timescale. The design activities and information dependences in complex building projects can be represented on a dependency structure matrix (DSM) because the design process model in the first stage of the analytical design planning technique (ADePT) covers a wide range of building systems. It was found that practising designers and design managers shown the DSM methodology and tools have been enthusiastic about the effectiveness of the approach and detailed level of information that is represented.

The main findings from the Managing Design in the Extended Enterprise process indicate that to achieve innovation and design quality standards in construction, some principal requirements need to be set in place. The relationships between design and all other stakeholders need to be managed from concept to delivery. For the desired level of innovation, the criteria of quality must be understood and translated into both tangible and intangible terms. Quality criteria must be set and translated at the onset and measured at the stages along the process.

Managing design and design quality is primarily about understanding what is required and setting in place the right process, people and support technology to achieve it. The process protocol must be determined at the onset in order to prepare for the type of design relationships within the extended enterprise. Creative design ideas, technology innovation and improved quality result from well managed design relationships.

Through the integration of a number of different research components covering process mapping, Supply Chain Management (SCM) and value engineering, a view of how the industry could move forward and work together in a more integrated fashion to design and deliver products was analysed. Some ideas were found to be are common sense and reflect existing practise whereas others represent new ideas, atleast to the construction industry. Integrated Collaborative Design (ICD) provides a cohesive framework in which many current business improvement methods can be harnessed to provide benefits to the construction organizations and hence deliver greater value to its customers as well as leading to significant ongoing research into value and design quality management (Thompson et al., 2006). Whilst the totality of the Integrated Collaborative Design (ICD) as an approach was not applied, its various components
have been applied, such as in the realm of mapping design information flows and much of the practises are being applied across the construction sector. Thus, the Integrated Collaborative Design (ICD) is viewed as a means of integrating these many new and existing practises to provide a coherent approach that places design at the centre of project management.

An Integrated Design Management Tool called DePlan offers a combined planning, scheduling and control methodology for integrated design management. Research has shown that this can be achieved by blending two established methods—Last Planner and the Analytical Design Planning Technique (ADePT). Prototype software has been developed to verify the approach and undertake validation exercises. The methodology can add rigor and transparency to the management process and provides an opportunity to achieve greater integration of design in the supply chain.

Through the implementation of the prototype tool, it was found that the Web-based Interface Management System ‘diMs’ process and tool is effective in assisting the design team to proactively identify, organize and document the design interface information of the construction design. In addition to the standard partitioning and tearing which are available in most Design Structure Matrix (DSM) software, the reports generated out of the ‘diMs’ methodology guides the designers to identify and prioritize the interface issues to be discussed during regular weekly interface meetings. The focus on these interface issues during the meeting ensures a timely resolution in a collaborative manner.

The findings indicate that without the aid of the tool, the manual process of identifying and prioritizing the interface issues is tedious and time consuming. The solutions made are recorded and taken as a reference throughout the design process in order to ensure the integrity of various design stages.

All the major components of the tool—the database, communication engine, process templates, response formats and other supporting documents are web based, providing location independence, secure multi-user access, and other benefits required by the process. It was found that utilization of the tool for large construction projects is feasible.

It was found that Emergent Changes and Internal Changes were the main causes of the magnitude of design changes that occurred on the Medupi Structural Steel (Chapter 4, Section 4.4). The findings indicate that the magnitude of design changes that occurred could not have been expected, therefore were not planned for.

As stated in Section 4.4, the findings indicate a fairly even assessment of the system currently in place for managing design changes on Medupi. The majority of respondents indicated that the system currently in place is effective. This indicates reluctance from respondents to criticize a system that they have approved and put in place. This is apparent because the findings indicate that a design management tool/method would have effectively managed the magnitude of design
changes that occurred on Medupi. The findings also indicate that a design management tool/method could have reduced the likelihood of disputes over design changes.

It was found that Global Collaboration had a big impact on the magnitude of design changes that occurred on Medupi. This further illustrated the importance of the use of a design management tool/method on a global collaborative project like Medupi or similar projects.

The study indicates that the Web-based Interface System ‘diMs’ is the tool most likely to effectively manage design changes on a global collaborative projects like Medupi other similar global collaborative projects.

5.3 Conclusions

The conclusions derived from the study are:

- Design Management is an area of engineering and project management that needs urgent attention, especially when global collaborative projects are to be executed.
- Emergent Changes and Internal Changes were the main causes of design changes on the Structural Steel component of the Medupi project. These were changes made to achieve project objectives, fix deficiencies, to correct errors, and to leverage misunderstandings between different design domains. (Section 4.3.1)
- The magnitude of design changes that occurred on the Medupi Structural Steel could not have been expected and planned for (Section 4.3.2).
- A design management tool/method would have effectively managed the magnitude of design changes that occurred on Medupi (Section 4.3.2).
- A design management tool/method could have reduced the likelihood of disputes over design changes (Section 4.3.2).
- Global Collaboration had a big impact on the magnitude of design changes that occurred on Medupi (4.3.2).
- The Web-based Interface System ‘diMs’ was the tool most likely to effectively manage design changes on a global collaborative projects like Medupi other similar global collaborative projects (Section 4.3.3).

In the final analysis, from the empirical and theoretical findings of the study, it was found that the system currently used by Murray & Roberts for managing design changes was ineffective. There is a need for a design management tool/method which would lead to less claims and disputes.

5.4 Recommendations

This section looks at the recommendations that can be made to stakeholders such as; Department of Energy and its departments; Eskom; Hitachi Power Europe; Murray & Roberts and all design contractors. This will enable the management of design to be enhanced and the running of
projects to be a much smoother operation. The recommendations are guided by the objectives of the study.

5.4.1 Root causes of design changes

The findings indicate that Emergent Changes and Internal Changes were the main causes of design changes on the Structural Steel component of the Medupi project. These changes were made to achieve project objectives, fix deficiencies, to correct errors, and to leverage misunderstandings between different design domains. Through interaction with the respondents, it was found that there were often clashes between the Electrical, Mechanical and Structural Steel components of the project. The design changes were mostly due to clashes between these designs domain.

This illustrates the need for a design management tool that will effectively manage the different design domain on projects, especially on global collaborative projects.

5.4.2 Design Management tools/systems

Through the literature review, it has been found that managing design changes is a very technical and complex issue. The following techniques, tools and models for managing design changes were identified and analysed:

1. Analytical Design Planning Technique (ADePT)
2. Integrated Collaborative Design (ICD)
3. DePlan: a tool for integrated design management
4. Managing Design in the Extended Enterprise
5. Web-based Interface Management System ‘diMs’

5.4.3 Appropriate Tool for Global Collaborative Projects

The findings indicate that the Web-based Interface Management System ‘diMs’ is the tool most suitable for effectively managing design changes on global collaborative projects. The Web-based Interface Management System ‘diMs’ process and tool is effective in assisting the design team to proactively identify, organize and document the design interface information of the construction design. In addition to the standard partitioning and tearing which are available in most Design Structure Matrix (DSM) software, the reports generated out of the ‘diMs’ methodology guides the designers to identify and prioritize the interface issues to be discussed during regular weekly interface meetings. The focus on these interface issues during the meeting ensures a timely resolution in a collaborative manner. Design Management tools are continuously being improved. It can be concluded that tools that have similar characteristics to the ‘diMs’ tool could potentially manage design changes on global collaborative projects.
5.5 Recommendation for further research

Although the study has attempted to address the issue of design management on global collaborative projects using Medupi as a case study, some issues could not be looked into. It is therefore recommended that future research take the following into consideration;

i. Improve Tool

The study has established that the Web-based system for interface management ‘diMs’ is the tool most likely to have managed the magnitude of design changes on the Medupi project. However, it is worth noting that ‘diMs’ was not developed specifically for global collaborative projects. Some improvements can be made to the tool, which could potentially make it even more suitable for these types of projects.

Based on the challenges experienced on the Medupi structural steel design, the following improvements would make the tool even more appropriate for global collaborative projects;

- Incorporate a feature for predicting future design changes
- Incorporate a feature for providing Impact Analysis of each design change
- Incorporate a feature for providing Change Traceability

5.5.2 Test tool on Global collaborative project

The recommended Web-based Interface Management Tool ‘diMs’ should be tested on a global collaborative project. The tool can then be thoroughly assessed in order to determine its suitability. The ability of the tool to manage the magnitude of design changes that occurred on a project like Medupi will determine its suitability. It can then be assessed whether the tool has reduced disputes caused by design changes.
5.6 Concluding Remark

This research report has identified and analyzed design management tools/methods. The main purpose of this was to identify a tool which was appropriate for effectively managing the design changes that occurred on a global collaborative project like Medupi.

Medupi is the biggest construction project ever to be executed in South Africa. The magnitude of design changes that occurred on this project were not expected. Similar projects to Medupi like Kusile are currently being constructed. Eskom has a big Power Grid programme, which entails construction of more Power Stations.

As has been previously stated in this study, no project is impeccable. Changes are going to occur, whether it is in design or the construction process. It is imperative that the South African construction industry becomes proactive rather than reactive. The use of a design management tool/method would significantly reduce the likelihood of disputes of design changes, therefore leading to successful completion of projects. It is of the utmost importance that we learn from the challenges experienced on Medupi in order to have a smoother execution of projects in future.

Finally, an evaluation of the root causes of design changes that occurred on Medupi, analysis of design management tools/methods and selection of the Web-based Interface Management System ‘diMs’ as the tool most likely to effectively manage design changes on Medupi, will help those responsible for successfully delivering future global collaborative projects.