COLLABORATIVE RISK MANAGEMENT WITHIN THE DESIGN PHASE OF GREEN BUILDINGS

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Green building projects are ambitious in terms of the complexity of structures, design requirements, information flows, stakeholder integration and technological integration. As a consequence, management of these projects is becoming increasingly integrated. However, risk management (RM) has taken little account of these emergent interconnected stakeholders, interdependent tasks, inseparable risks and iteration in the design process. This leads to poor risk management outcomes, where traditional risk management practices that rely on allocating risks to specific individual entities are not able to accommodate the complexities of a collaborative integrated design. As part of a comprehensive research into how project stakeholders in collaborative design teams manage inseparable risks within their interdependent design tasks, multiple case studies were analysed using empirical data from semi-structured interviews of experienced practitioners. The abductive approach provided explanations of the continuous interplay between theory and various real-life examples. To bridge the current research gap, a matrix-based approach of using Dependency Structure Matrix to integrate the stakeholder dimension and the task dimension to solve for inseparable risks, enabled Collaborative Risk Management (CRM) to filter out most complexities, so that efforts could be directed to appropriate risk sharing and analysis of important parts of the design process. In order to judge the collaborative climate and satisfaction of each stakeholder in the design team, stakeholders suggested a decentralized process that foster a co-operative culture, contract negotiation and communication as key to ensuring that all parties are able to perform their respective tasks adequately. To manage inseparable risk, stakeholders suggested proportional risk sharing approaches, regular team meetings and timeous information sharing. The project should have a shared insurance cover that will balance the risks fairly between stakeholders; in absence of bad faith; leading to a reasonable price; qualitative performance and the minimization of disputes.

Keywords: collaboration; design tasks; long-term relationships; risk sharing

INTRODUCTION

Green building (GB) is defined as a process aiming to reduce the overall impact of the built environment on human health and the natural environment by efficiently using energy, water, and other resources and by reducing waste, pollution and environmental degradation (GBCSA, 2007). The design component of this process involves complex and comprehensive work activities requiring the cooperation of various specialties as collaborating stakeholders (Liu *et al.,* 2014). The multifaceted

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nature of green project designs has become increasingly difficult as it involves extensive interdependence of design information and design tasks across a large number of design disciplines requiring a major shift towards collaborative design approaches (El-Diraby *et al.,* 2017). However, the traditionally used planning methods such as CPM and PERT cannot model the iterative nature of design processes (Senthilkumar *et al.,* 2010), and similarly, risk management has not adapted to these new approaches to better cope with this increased complexity and interdependence. This study intends to explore how project stakeholders in collaborative teams manage inseparable risks within their different design tasks on green buildings and how the use of Dependency Structure Matrices (DSM) can be effective in representing both the design process and management of risk within the design processes.

Collaborative designs used in GB projects demand processes of coordination and cooperation of different stakeholders who share their knowledge in both design process and design content (Kleinmann, 2006) as a means of attaining the unified design goals in the most efficient and effective ways (Liu *et al.,* 2014). Traditionally risk management has given little consideration to the nature of collaboration within the interdisciplinary and iterative design process. Risk management practices continues to rely on allocating risks to specific individual entities (individuals or design disciplines), which is increasingly problematic given the non-coherence of the growing green building sector, where the design philosophy is holistic and treats the building as a complex integrated system (El-Diraby *et al.,* 2017), that is best designed, and efficiently executed through collaborative practices.

Green buildings foster the habit of collaboration and optimization among all building measures (Korkmaz *et al.,* 2010). Optimization is an inherently iterative process in collaborative green designs, assisting in the progressive generation of knowledge, enabling a degree of concurrency and collaboration (Wynn and Eckert, 2017). Chiu (2002) defined collaboration "as an activity that requires participation of individuals for sharing information and organizing design tasks and resources."(ibid: 187) This means that the stakeholders provide each other with new insights that enable each participant to fulfil his or her own design tasks without compromising the design of others whilst meeting the common objectives of green building. These objectives are typically to; lower energy consumption, lower investment costs, and reduced harmful impacts on the environment and on people (EPBD, 2015). In collaborative green designs, tasks are interdependent and iterative; with risks that are intricately connected (Al Hattab and Hamzeh, 2015). These risks are inseparable and cannot be transferred or allocated to an individual but have to be shared between stakeholders and can only be resolved or mitigated through collaboration (Laurent, 2017). To understand inseparable risks, it is helpful to identify the interconnected stakeholders and interdependent tasks as well as their effects. Since RM still have limitations for modelling the complexities of inseparable risks; these risks need dynamic management over time. This dynamic approach needs effective risk management and collaborative efforts among project stakeholders (Lam *et al.,* 2007; Gomes *et al.,* 2016). Such Collaborative Risk Management (CRM) is the dynamic management of risk (Rahman and Kumaraswamy, 2005) and plays a major role in achieving value-for-money and cost-efficiency in designing complex projects.

However, a good number of existing risk analysis methods are restricted to one of the two dimensions, namely, stakeholder and task, which also can reduce the effectiveness of risk management. Some methods represent the stakeholder dimension, quantitatively evaluating the networks formed by stakeholders and their relationships but doesn't meet the dynamic changing characteristics of the network caused by the risk factors. At the same time, other methods focus on the task dimension, analysing the risk factors in the design phase and presenting risk mitigation actions. Yes, these do not reflect the interdependency of stakeholders and their interdependent tasks that give rise to inseparable risks and, they cannot portray the interrelationships between them and are thus unable to model complex interactions. Hence the need for a matrix-based approach using DSM to integrate both the stakeholder dimension and the task dimension to solve for inseparable risks, using a CRM method to improve the accuracy of risk analysis and the effectiveness of risk management.

The DSM tool is capable of dealing with a design process comprising thousands of activities and still be able to prioritize dependences (Austin *et al.,* 2000). Thus, CRM and DSM are powerful methods to solve for inseparable risks. The amalgamation of both approaches could result in an extremely powerful tool that can lead to technical, managerial, and economic benefits. The tool should also provide insights into the projects in a manageable way that all stakeholders can benefit from. Further, DSM has been shown to provide a better planning methodology for risk sharing decisions (Maheswari and Varghese, 2005).

Collaborative Risk Management within Green Buildings

Green Building designs are complex undertakings that have given rise to reciprocal interdependencies between multiple and diverse stakeholders, hence the high dependence on information, followed by the connectedness of tasks (Austin *et al.,* 2002; Ahn *et al.,* 2016). Bakhshi *et al.,* (2016) defines GBs' complexity as an intricate arrangement of the varied interrelated parts in which the elements can change and evolve constantly with an effect on project objectives. Yet, they are the most effective solutions to increase the efficiency of buildings through resource utilization and recycling, mitigating the negative impact of the construction industry on the environment (Zuo and Zhao, 2014). This has been made possible by through, inter alia; mutual collaboration, adjustments towards working collectively and responding to emergent, unforeseen problems in real-time. However, project realities are such that current risk practices promote competitive attitudes between the project stakeholders involved because they tend to work for their self-interests and thus safeguard their existence in the project life (Alsalman 2012). So, it is vital to change, not only risk management (RM) practices, but the associated mindsets to shift towards mutual adjustment and rapid adaptation, where stakeholders will be in a give-and-take interdependence (Morris 2013). The change from traditional RM to CRM is loaded with uncertainties on risk sharing among all project stakeholders and their response to this requires a cultural shift in how they approach the sharing and management of risk.

This cultural shift towards risk sharing requires all stakeholders within complex projects to take a closer look at their own risk universes. Risk sharing is a useful method for handling complex designs (Melese *et al.,* 2016). It is a collaborative way of managing risks which have an ability to take advantage of the different views from different stakeholders (Olander, 2007) and it also identifies risks that cannot just be shifted to one stakeholder but have to be collaboratively managed (Lam *et al.,* 2007). CRM appears to be a relevant problem as it emphasizes equitable and balanced risk sharing among contracting stakeholders and who wants to eliminate improper or unfavourable risk sharing outcomes which result in cost and time overrun and, undoubtedly, in legal disputes (Loosemore and McCarthy, 2008).

In this vein, the traditional tools (PERT, Gantt and CPM) are based on linear workflows; however, they have failed to address interdependency (feedback and iteration) and will would not be suitable for modelling information flows which those controls determine the design phase (Yassine *et al.,* 1999). A DSM will can be employed as a useful tool for coping with design issues (Steward, 1981). The matrix can be used to identify appropriate stakeholders, teams, and the ideal sequence of the tasks (Lindemann, 2009). A DSM involves a square matrix with an equal number of rows and columns that shows relationships between tasks in a system, and with interest, risks (Eppinger and Browning, 2012). Collectively, these complexities and interdependencies of tasks have resulted in inseparable design risks that would have to be shared collaboratively. How then do project stakeholders in collaborative teams deal with inseparable risks within their different design tasks?

Managing Risk using Collaborative Risk Management Principles

The emphasis of effective RM in dealing with the broad spectrum of risks is to move beyond the traditional RM mechanics to examine the sources of unknown risks (Jarkas and Haupt 2015). Though the construction industry has long managed to identify and analyse known risks, it has recognized that dealing with the hidden, less obvious aspects of uncertainty is complicated and results in inseparable risks, and this requires practitioners to be more proactive in their approach (Smith and Merritt 2002).

In practice, a typical approach to risks is trying to identify them as early as possible and respond to them as quickly as possible once identified (Kim, 2017). However, green projects anticipate unidentified risks, also known as 'unknown unknowns' that have traditionally been underemphasized by risk management (Thamhain, 2013). It is difficult to trace the causes and culprits of these unknown unknowns as they require inventive risk handling decisions on risk allocation (Jin *et al.,* 2017). Predicting and controlling such unknown risks has also developed impractical risk preferences for some project stakeholders because they sometimes actively ignore them (Alles 2009). These risk attitudes have made the risk sharing process challenging (Walker, 2015), as shown in Fig 1.

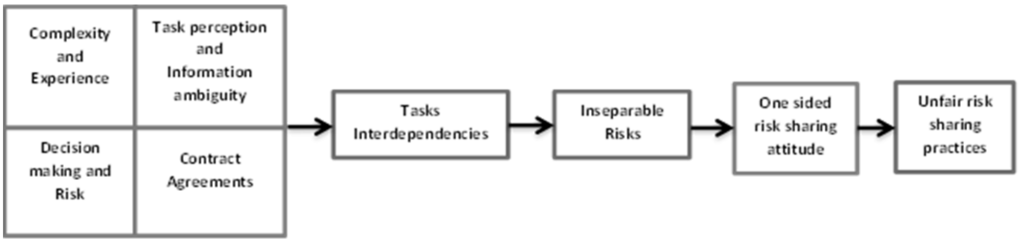

Fig 1: Interdependent tasks and risks can lead to an unfair risk sharing situations

The goal of identifying inseparable risks is to make the process of risk sharing more efficient through planning and coordination by mutual adjustment, so as to get a better information flow in design (Fundli and Drevland 2014). Design risks have been classified in a number of ways. Arguing that risks arise as a result of interactions between stakeholders, obsolete technology and organizational factors, Smith *et al.,* (2009) suggest that they may be grouped as either involuntary or voluntary, depending on whether the incidents that create the risk are uncertain or beyond the control of the people in charge.

The increasing complexity of projects and knowledge processes, makes it imperative for stakeholders to be keenly aware of the intricate connections of risk variables among complex systems and processes (Thamhain 2013), this limits the effectiveness of traditional RM methods. Stakeholders argue that no single person has all the smarts and insight for assessing multi-variable risks and their cascading effects (Hartono *et al.,* 2014). Project stakeholders realize that, while there may be good RM methods which provide a critically important toolset for risk management, it takes the collective thinking and collaboration of all the stakeholders to identify and deal with the complexity of inseparable risks in green building projects.

RESEARCH METHOD AND DATA ANALYSIS

In order to execute this study, a multiple case study approach was adopted, where real-life events showed different perspectives to enhance and support the different results from the semi-structured interviews (Zainal, 2007). The approach helped in testing the process which commenced with established RM theory, advancing the application of CRM in green projects. Participants were asked about their stakeholder techniques on carrying out inseparable tasks, as well as their options and suggestions on CRM processes of green projects. The underlying intention being to acquire in-depth knowledge for strong theory building (Amaratunga *et al.,* 2002).

CRM is a relatively innovative concept in South Africa, and, in the different case studies, it was important to obtain a detailed and comprehensive view of it by investigating it in past and ongoing projects. The completed projects are the residential apartments and the commercial development; and the project team of this case study reflects on the problems they faced. The other case studies were an academic pathology facility and the retirement apartments; these projects are in their design phases and the project teams are still engaging with their risks and experiences. In all projects, many stakeholders with various backgrounds were involved to see how their thought CRM could be applied.

The adoption of multiple case studies not only helped to explore or describe the data in a real-life environment but also to take multiple perspectives to the CRM progression like the complexities of real-life situations, the case studies, matrix-based applications and the reviewed literature to see a bigger picture (Stake, 1995; Zainal, 2007). It provided a stronger foundation for theory building, specifically, when solving design problems that have a holistic approach due to their integration in design and different stakeholders facing complexities and task interdependencies, which resulted in inseparable risks. In this instance, multiple case studies sought to understand the lived experiences of various stakeholders who have a shared experience of green building construction across different cases, with suggestions of a plausible process to understanding CRM as an effective RM practice (Chong, 1994).

The analysis and interpretation of research data form the major part of the research (Amaratunga *et al.,* 2002). The methodical process used was the DSM, which is a square matrix that focuses on dependencies between elements of one domain like task-task sequence relationships. Then, the Domain Mapping Matrix (DMM) was used as it examines the interactions across domains to represent enriched analysis results that provide an expanded view of the complex system (Bartolomei *et al.,* 2007). When applied, a DMM was constructed to map out the interdependencies, interactions, and exchange of information from design tasks and risks, identifying the optimal sequence of tasks, risk interactions and iterations across domains (Yang *et al.,* 2014). The combination of square DSM and rectangular DMM is called Multiple Domain Matrix (MDM) where useful information and transformation of flow is provided using intra- and inter-domain networks (Lindemann and Maurer, 2007), as shown in Table 1.

Table 1: MDM Mapping System for capturing the Design Process Interfaces in various domains headings

	Stakeholders	Design Tasks	Design Components
Stakeholders	People DSM	People-Activity DMM	People-Design-Components DMM
Design Tasks		Activity DSM	Activity-Design-Components DMM
Design Components			Component DSM

The MDM provides valuable and structured information regarding the intended designs between different stakeholders, their design tasks and the design component domains. This reduces the required effort to construct high-definition DSMs. Also, the DMM process was utilized to identify clusters (Browning, 2015) in a matrix analysis approach that minimizes iterations and enhances efficiency in risk management (Jaber *et al.,* 2015). The high interaction of clusters encouraged stakeholders to collaborate, communicate and coordinate better, so to identify and examine interfaces between the clusters and keep iterations at a minimum; minimizing the number of task dependencies (Austin *et al.,* 2001).

FINDINGS AND DISCUSSION

A total of 27 semi-structured interviews with different practitioners from the case studies and referrals were conducted, using a non-probability, snowballing sampling technique. These participants were involved in green building project designs. In addition to their knowledge and experience, the importance of availability and willingness to participate, and the ability to communicate experiences and opinions reflectively was also important; to understand the current risk sharing practices and the way inseparable risks can be managed in collaborative circumstances. The completed case studies were green building projects that were certified with an in-depth certification scheme that addresses all 9 categories of Green Star tools. The tools are based on 9 different categories, each with a range of credits that address environmental and sustainability aspects of designing, constructing and operating a building. In the cases that were still in their design phase, a design will have a certification of validated environmental initiatives.

In real life, practitioners are dealing simultaneously with risks in several dimensions. These risks are about issues of how to organize people in different simultaneous design processes. Moreover, how to manage the process of inseparable risks? How to organize the interdisciplinary environment, and lastly how to coordinate people and integrate their tasks in many interrelated processes? To manage all these dimensions, a Multiple Domain Matrix mapping system is included to improve design process understanding and communication. The case studies revealed that, to manage inseparable design risks, stakeholders suggested co-location, improved co-ordination between disciplines, as well as getting GB accreditation training where attendees have the opportunity to discuss and become familiar with suitable practices of design and risk. Furthermore, Effective, regular, and planned communication with all members of the project community is necessary to reduce the levels of uncertainty and promote collective thinking and collaboration. Yet, there are still hindering factors that impede risk-sharing implementation as shown on Table 2. In seeking a new dimension for the study of collaborative risk management, GB design processes are chosen as a focus application area for exploration because of their strong influence on risk sharing agreements.

Table 2: MDM of what impedes risk-sharing implementation

What impedes Risk Sharing	Contract Negotiation	Communication	Stakeholder Management	Green Building Development	Continuous Training	Mandatory GB Assessment	Regular team meetings	Unified design codes	Collaborative engagements	Shared insurance	Risk sharing capacity
Restrictive contractual clauses	x		x								
Clarity of roles	x	x	x				x				
Differing risk attitudes		x	x								
Client knowledge				x		x		x		x	
Green building skills			x		x	x		x			
Standardize application processes of GB	x	x	x	x	x	x	x	x			
Information sharing		x	x				x				
Design Variations		x	x	x	x	x	x	x			
Government bureaucracy		x	x				x		x		
GB specific insurance			x							x	
Unfair risk sharing		x	x								x

To handle the dynamics of complexity, after the mapping of the interdependencies in the matrix, rows and columns were then altered optimised in order to find clusters that are highly related to each other, to enable coordination. Stakeholder knowledge and perception of inseparable risks can be organized to promote mutual understanding and communication based on completed projects and projects still in the design phase. Management of GBs stress’s structure and quality communication systems.

Optimal CRM arrangements are on cognizing stakeholders’ behaviour, where respondents highlighted that project teams with shared responsibility, should initiate, develop and implement collaborative practices that regularly evaluate each other's roles and responsibilities and accept joint responsibilities for the team's achievement. To ensure such shared responsibility, all stakeholders should embrace collaborative attitudes such as decision synchronizing that focus on finding solutions when problems occur, risk management practices that are open to risk sharing agreements that are flexible and can lead to equitable risk sharing, as shown in Fig 2.

Fig 2: MDM of what impedes risk-sharing implementation

To achieve equitable risk sharing, CRM aims to deliver superior value by assembling, integrating and harnessing the collective skills and capabilities of all stakeholders by effective utilization of technology, unique leadership and communication. However, risk-sharing practices in a CRM arrangement cannot be considered individually but must be correlated between different RM practices. The interaction between these practices means there are different constraints considered to create a balance among the selected practices. These constraints attempt to consider prerequisites between risk-sharing practices and further prevent the selection of antithetical practices.

CONCLUSION

Green design complexities have driven the industry to open systems that commanded collaboration and thus, have resulted in interdependency and risk. However, existing project management practices fail to incorporate complexity-based thinking and collaborative practices into risk management. This has led to poor risk management outcomes, where traditional risk management practices that rely on allocating risks to specific individual entities are not able to accommodate the collaborative facets. The DSM method was used to identify interdependencies and relations between items such as tasks, activities, risks and among designers and design teams. The parameters in inseparable risk networks were considered to give priority to certain risks and design more effective response actions. Mapping this information dependence revealed the underlying structure for design processes and the design teams setting was designed on the basis of this structure. However, tasks, specifications, and processes changed when new information was introduced. While the design process can be dynamic, the application of DSM, DMM or both is instant. To handle the dynamics of CDM, DSM and DMM analyses would need to have been done repeatedly. Should this be done, then this approach would be able to support stakeholders in making decisions, such as risk response planning and allocating available budget or resources. CRM encourages people to meet, communicate and coordinate better, to manage potential interactions. It underlines the need for cooperation and transversal communication in the design teams. Interviews prove that it does indeed improve communication between stakeholders and the understanding of responsibility and accountability.

This change of paradigm does not take place naturally or without resistance as the findings show that some professionals see CRM as an extreme alternative to current practice as it involves risk sharing. Future developments in collaboration will lead to the widespread use of CRM principles in project management. Direction for actions of people will come from the intensive interaction and understanding of the design context, not from orders of the hierarchy structure bur rather from the knowledge of the end user's needs.

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