

THE UNIVERSITY OF CAPE TOWN

Faculty of Engineering and the Built Environment

**“A Study of Risk Perceptions and Communication
in Risk Management for Construction Projects.”**

Peter John Edwards

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DECLARATION.

The content of this thesis is entirely my own work, except for the specific and acknowledged references to the published work of others.

I confirm that no part of this thesis has been submitted to any other institution for academic award of any kind.

Signed at *Melbourne*.....this *31st* day of *January*....., 2001

Peter John Edwards.....

Signed by candidate

.....

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ABSTRACT

Since the activities of people, in the context of achieving pre-determined objectives, always give rise to the possibility (and thus probability) that events with adverse outcomes will occur, then risk must be seen as a social construct. The likely occurrence and impacts of risks may be interpreted and valued differently by different people, whose responses to those risks may also be different. Construction projects, in the context of the decision-making and organisational structures which comprise such undertakings, follow this view of risk. Project stakeholders, as the entities whose decision-making activities directly influence project outcomes, are exposed to risk in many forms. The ways in which those risks are perceived, understood and communicated may affect the management of project risks, and hence the success of the project itself.

This research explores risk and risk management and, in particular, the perceptions, understanding and communication of risk among key stakeholders in construction projects.

A broadly ethnographic research methodology has been used, comprising discursive review of appropriate literature, a questionnaire survey and case studies of construction projects.

The research findings indicate that differences do exist in the risk perceptions of the various clients, consultants and contractors involved in construction projects. There is a lack of maturity and expertise in risk management internationally in the construction industry, and little or no adoption of systematic approaches to dealing with risk. Despite the fact that not all construction projects are high risk endeavours, failure to maintain effective formal risk management systems endangers projects in that risks may be overlooked, and the learning value of risk experiences may be locked into individuals rather than becoming a core asset of the organisation. Greater transparency of risk communication between project stakeholders would benefit projects and the construction industry generally.

Construction and project management has much to learn from risk management in other fields and should avoid a xenophobic view or approach. In this regard, a generic approach to categorising risks by their type of source (or trigger) is useful as aid to risk identification, analysis and response. Natural risks include all risk events occurring outside the field of human endeavour. Generic categories of human risk would comprise: social, political, economic, financial, legal, health, managerial, technical, and cultural risks.

Future research might usefully focus upon a better theory of practice of risk management for the construction industry, to resolve the impediments to the adoption of a more systematic approach.

PUBLICATIONS ASSOCIATED WITH THIS THESIS

Parts of the work of this thesis have been published in other media, using the normal student/supervisor protocols. Publications to date include:

Edwards, P.J. and Bowen, P.A. (1998) Risk and risk management in construction: review and future directions for research. *Journal of Engineering, Construction and Architectural Management*. 5. (4) 339-349. (This publication is based upon early drafts of part of the work contained in Chapter 3 of this thesis.)

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Edwards, P.J. and Bowen, P.A. (1999) Risk and risk management in construction: concepts, terms and risk categories re-defined. *Journal of Construction Procurement*. 5. (1) May. 42-57. (This publication is based upon early drafts of part of the work contained in Chapter 2 of this thesis.)

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CHAPTER 1

INTRODUCTION

1.1. Risk and risk management.

"*Risk is the probability that an adverse event occurs during a stated period of time.*" (Royal Society, 1991). It follows from this definition that three things are common to all risk situations. First, the occurrence of the event is subject to some degree of chance. Second, if it does occur, the event outcome will be adverse, ie. it will result in some sort of loss for the risk-taker. Third, while its precise occurrence may be known or unknown, the event is temporally framed. Given the first statement, the temporal placement lies at some time in the future.

Two further characteristics of risk are that it is *social* and *dynamic*. People (and organisations) experience risk and can *learn* from their experiences, ie. current decisions about future risks may be informed by past risk outcomes - assuming similar historical risk events have occurred. Risk is therefore a *social construct* (Royal Society, 1991), and is thus susceptible to human interpretation and management.

Risk is *dynamic* in that two of the elements of risk - probability and magnitude of outcome - are not necessarily fixed in or over the third element - time. The probability of occurrence for some risks may increase or decrease with the passing of time; as may their impacts. Some risks may be associated with a single event on a single occasion. Others may occur repeatedly on repeated occasions. Yet again, the impact of some risks may be continuous once the trigger event has occurred.

Risk management is the process which enables a risk-taker to pursue an informed approach to risk situations, with a view to controlling risk, or optimising decisions about risk. Intrinsically, risk management can only be undertaken by the risk-taker but, in the construction industry, the term has become a descriptor for specialised risk advisory services offered on a professional consultancy basis to project clients. In this context, therefore, *risk managers* are not necessarily the same people as *risk-takers*.

The literature (e.g. Ranasinghe, 1990; Berkeley *et al.*, 1991; Betts and McGeorge, 1991; Birnie and Yates, 1991; Waldy, 1991; Macgregor, 1991; Betts and Gunner, 1993; Flanagan and Norman, 1994; Raftery, 1994;) advocates a fairly standard approach to construction project risk management, comprising the identification of project risks; the analytical study of those risks; the exploration of alternative risk responses; and the advocacy and adoption of a specific response. However, while these authors encourage the establishment of the client's *risk profile*, most adopt a "hard systems" view (Green, 1994) of risk management which is largely objective and quantitative. This is also reflected in the predominantly mathematical nature of many risk assessment models. Similarly, through the hard systems approach, risk management has the objective of *controlling* risk. Approaches such as these constitute a risk management paradigm which is subjected to critical discussion in this thesis, where a softer paradigm of risk *understanding*, perception and communication is explored in a construction project environment.

Mak (1992), in his study of subjective judgement in risk management, showed that purely numerical outcomes to risk analysis could be affected by linguistic and subjective inconsistencies. To date, however, the construction project risk management literature has tended to ignore the subjective, perceptual and attitudinal "soft systems" aspects of risk, which aim at *enabling* or *facilitating* the risk-taker's decision-making. Writers may have been deceived by the admittedly hard systems characteristics of construction *technology*, but risk always has a perceptual, behavioural (i.e. social) context which cannot be ignored. Fischhoff *et al.* (1981) note that *values* play an important part in deciding upon acceptable levels of risk associated with introducing new technologies. Construction risk therefore has a *social* dimension which is as important as its technical characteristics. The work of Birnie (1994), Loosemore (1995) and Raftery (1993; 1995) supports this view. The wider field of construction management has already begun to embrace a soft systems approach as part of its research paradigm (e.g. Green, 1994; Hall and Bowen, 1994; Loosemore, 1995).

Individual perceptions of risk arise out of intra-personal processes. These may be influenced by prior risk experiences and by inter-personal communication between, for example, the risk taker and his or her advisors. Nevertheless, even though the purpose of all communication is to achieve shared meaning and exert influence, the reaction of message receivers may not match the intentions of message senders. In all corporate risk management situations, intra- and inter-personal communication processes will take place in order to impart meaning and understanding to the identification and analysis of potential risks, and to the exploration of alternative risk responses. For construction projects, such risk management occurs in a multi-disciplinary environment which may be based upon the appointment of separate consultancies (in terms of the

design team, for example). These participants come together in what are essentially goal-directed, temporary management structures (Hall, 1993). Their previous risk experiences may be unrelated to one another, or irrelevant to the current project. Given the fragmented and dynamic nature of the construction industry (Hillebrandt, 1985), and the scale and complexity of many construction projects, the quality of communication becomes a critical factor (Bowen, 1993).

It should be noted that there is no intention in this thesis to assume a view that formal risk management systems are essential for construction projects. They are used in the investigation simply because they exist and can act as a convenient benchmark for observing to what extent a systematic risk management approach has been adopted for projects.

1.2. The research problem.

If the construction industry persists in concentrating solely upon a “hard systems” quantitative approach to risk management, it is unlikely that a truly convergent understanding of risk will be achieved between the participants on a construction project. Risks will not be fully known and understood; and there will be an inability to properly appraise them. The effectiveness of project risk management is therefore endangered. This is particularly so if the practice of risk management is itself poorly systematised. The consequences of this are likely to be both economic and social; ie. in the complex processes of project communication, risks may be over-stated, and potential profit thus foregone; or they may be under-stated, and lead to financial loss. In either case, the potential arises for conflict and dispute, with clients and consultants dissatisfied with their involvement in the building procurement process and negatively conditioned towards future projects.

The problem to be researched can therefore be stated as follows:

Construction risk management is poorly understood and poorly systematised in practice. As a consequence, the proper management of risk among project stakeholders may be negatively affected.

1.3. The research questions.

The research questions are formulated thus:

If construction projects are multi-faceted (in terms of the role players who participate in them) then:

- (1) Do individual members of project teams have different perceptions of construction risk?*
- (2) How are these perceptions communicated within a project environment?*
- (3) To what extent is risk understanding influenced by stakeholders' prior risk experiences?*
- (4) If different risk perceptions exist, how does this affect the project decision-making?*

Subsidiary questions to be addressed include:

- (1) What are risk and risk management?*
- (2) What are construction projects and their environments?*
- (3) What are project and construction risks?*
- (4) Who are the project participants and how does project decision-making occur?*
- (5) What has other research in this field revealed?*

1.4. The research propositions.

This research is not hypothesis-driven since there is no intention to prove or dis-prove particular theories about risk and risk management. It is more concerned with seeking to augment a theory of practice for risk management in the context of construction projects.

The propositions to be tested by this research are:

- (1) Stakeholders (e.g. Client and project team members) in a construction project do not share common perceptions of project risks*
- (2) Stakeholders' prior risk experiences will influence project decision-making.*

1.5. Research objectives.

The objectives of the research are:

- (1) to extend the present theoretical foundation of construction and project risk management; and*
- (2) to gain insight into factors which affect the effective management of construction risk.*

1.6. Aims.

The intended aims of this research are to show how the outcomes of the investigation can:

improve risk management procedures for construction projects; encourage a more informed understanding of risk for project participants, and facilitate better project decision-making.

1.7. Research methodology.

The methodology for the research is broadly ethnographic. It comprises discursive review of appropriate literature, a questionnaire survey and case studies of construction projects.

Specifically this includes:

- (1) A focussed literature review of risk and risk management for construction projects.
- (2) A focussed literature review of decision-making and communication in construction project procurement systems (in a risk management context).
- (3) A focussed literature review of formal communication of risk allocation in construction contracts.
- (4) A questionnaire survey of risk and risk management perceptions.
- (5) Case studies of project stakeholder practices in three construction projects.

1.8. Theoretical frameworks and limitations.

The study attempts to bring the “soft system”, or human, aspects of decision theory and communication theory to bear upon the risks associated with construction projects. It is a qualitative, rather than a quantitative, study and is not primarily concerned with the mathematical treatment of risk, except insofar as this influences the perceptions and actions of project participants. The evidence of this limitation is found in Chapters 3 and 4, leading to the justification of the research designs in Chapter 5 and 7.

The research is also intended to explore construction and risk management from a *proactive* viewpoint, and not from a *post* risk event *reactive* stance. Except for stakeholder risk “stories”, the investigative focus will be more upon the “up front” phases of projects (ie. the pre-construction design and documentation stages) rather than the post-tender construction and post-contract operational stages.

1.9. Thesis structure.

The thesis is structured as nine sections, or chapters.

In **Chapter 1**, a brief outline of the research topic is given, followed by succinct statements of the research problem; the research questions; and the research propositions. The aims and objectives of the research are defined; and are followed by a short description of the research methodology.

Chapter 2 addresses the subsidiary question: *What are risk and risk management?* The chapter comprises a discursive treatment of concepts of risk and uncertainty, and the processes of risk analysis and risk management; in order to establish a definitive framework. The categorisation of risk is explored.

A review of the literature of construction and project risk management and risk research is provided in **Chapter 3**; covering applications of theoretical techniques, risk management systems, and the development of a “soft systems” research approach. This chapter largely addresses the subsidiary questions: *What are project and construction risks?* and *What has other research in this field revealed?*

The process of decision-making in the project environment of building procurement systems is explored in **Chapter 4**, thus addressing the subsidiary questions: *What are construction projects and their environments?* and *Who are the project participants and how does project decision-making occur?* The focus is on project and construction risks and the interpersonal communication surrounding them. The allocation of risks is discussed.

Chapter 5 draws together the principal issues raised in the previous chapters, and proposes an opinion survey based research design to address the research question: *Do individual members of project teams have different perceptions of construction risk?*

Chapter 6 comprises the analysis and interpretation of the questionnaire survey data, together with a discussion of the findings.

Chapter 7 describes a case study protocol to explore the remaining research questions on an *intra-project* and *inter-project* basis.

Chapter 8 comprises the analysis and interpretation of the case study data.

Concluding discussion is pursued in **Chapter 9**, and recommendations for risk management practice are made. This is followed by a full **Bibliography** for the thesis and an **Appendix** containing the survey research instrument (for South Africa).

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CHAPTER 2

RISK, RISK MANAGEMENT, AND RISK CATEGORISATION

2.1. Introduction.

In terms of publication in authoritative English-language media, the process of placing construction risk within the purview of decision theory and management theory dates from the early 1960's. Recent research, however, has shown that construction professionals still lack a sound understanding of risk and its terminology (Akintoye and MacLeod, 1997; Mok *et al.*, 1997). This suggests that there is a need to explore and expound the concepts of risk generally, and construction and project risk specifically.

The chapter commences with discussion of the concepts and definitions of risk; and argues the nature of uncertainty. Risk analysis and risk management are described and defined, followed by a proposal for source-based categories of construction and project risks. This work is an essential precursor for establishing the parameters of the research design proposed in Chapters 5 and 7, and the survey and case study data to be presented in Chapters 6 and 8. Essentially this chapter addresses the subsidiary question: *What are risk and risk management?*

2.2. Risk concepts.

Although Lifson and Shaifer (1982) note that the ancient Greek philosophers discussed uncertainty, and that Chinese mathematicians explored techniques of probability at least two thousand years ago, formal *a priori* understandings of risk, in terms of the associated mathematical probabilities and their treatment, date from the seventeenth century European mathematicians. Eves (1976) relates how Christiaan Huygens (1629-1695) explored the concept of mathematical expectation, and wrote his formal treatise on probability in 1657, later incorporated by Jakob Bernoulli (1654-1705) in the posthumously published work *Arcs coniectandi* (1713). The large Bernoulli family of mathematicians also included Nicholas, associated with initiating the problem of the "Petersburg paradox", which was subsequently addressed by his brother Daniel. Laplace (1749-1827) pursued an analytical theory of probability and Poisson (1781-1840) examined probability in the context of decision-making (judgement). In

the eighteenth century, the parson-mathematician Thomas Bayes produced his theory of the effect of introducing new information upon the use of probability to maximise expected return.

Scientific investigation of risk, in terms of human behaviour and decision-making under uncertainty, has been a much more recent undertaking. Von Neumann and Morgenstern (1944) reported early theories of human behaviour under conditions of economic uncertainty. Slovic (1972); Cohen (1979, 1981); Kahnemann and Tversky (1979); Tversky and Kahnemann (1981, 1983, 1986, 1991, 1992) and Kahnemann *et al.*(1982) have produced seminal work on human decision-making and judgement under uncertainty, with a focus on the pathology of heuristics and biases.

In the United Kingdom, the Royal Society has commissioned and published the findings of two studies into risk. The latter report (Royal Society, 1991) incorporates an essential *social* dimension of risk, proposing that risk is a social construct: an experience of society which demands human decisions in response. Risk is also pervasive, affecting every aspect of human endeavour. Perceptions of risk are therefore likely to vary widely among people of different backgrounds. Construction, with its temporary multi-structure organisational approach to building procurement, is particularly susceptible to variation in risk perception, and thus provides a rationale for seeking at least some definitional common ground.

2.2.1. Definitions of risk

Cooper and Chapman (1987) believe that: "*Risk is the exposure to the possibility of economic or financial loss or gain, physical damage or injury, or delay, as a consequence of the uncertainty associated with pursuing a particular course of action.*" It is difficult to accept their insistence upon the association of "gain" with risk, although a few other authoritative texts concur. Mawdesley *et al.* (1997) characterise risk as "loss" or "opportunity" (the latter for gain). Lifson and Shaifer (1982) define risk as: "*...the uncertainty associated with estimates of outcomes.*" and suggest that the meaning be expanded to include the chance that outcomes could be better than expected. Such a denotive broadening is undesirable. It weakens the normal objective of risk management - to mitigate (rather than seek) risk - and in practice is unlikely to be of great interest to project clients, even to those seeking appropriate financial return on their investments. In such cases, the better than expected outcome would really be windfall profit - a much less serious situation than potential loss. None of the authors who do advocate "upside" and "downside" (ie. gain and loss) understandings of risk actually present examples of the former.

According to the British Standard on risk (BS4778, 1991 Part 3 - in Royal Society, 1991), risk is: “a combination of the probability, or frequency, of the occurrence of a defined hazard and the magnitude of the consequences of the loss.” Here again the association of probability of occurrence with magnitude of outcome of the risk event is found; and now risk is seen in the context of “hazard”. No reference is made to uncertainty.

Two joint Australia/New Zealand standards deal with risk. Each offers different definitions of terms. AS/NZS 3931 (1995), which covers risk analysis of technological systems, defines risk as: “The combination of the frequency, or probability, of occurrence and the consequence of a specified hazardous event.”; and goes on to state that the concept of risk always incorporates two elements: probability (or frequency), and consequence. AS/NZS 4360 (1995), which deals with risk management, states that risk is: “the chance of something happening that will have an impact upon objectives. It is measured in terms of consequences and likelihood.” Here the notion of objectives is introduced, but this has to be seen in the risk management context of the Standard.

A dictionary definition of risk is provided by the Oxford English Dictionary (OED, 1989): “the chance or hazard of a commercial loss”. Two further contextual definitions are given: “exposure to mischance or peril”; and “the chance that is accepted in economic enterprise and is considered the source of profit”. It seems likely that the definition offered by Cooper and Chapman (1987) derives from an attempt to synthesise these alternatives, but the fact remains that none of the texts reviewed for this chapter presents examples of risk analysis dealing with purely positive outcomes.

The Royal Society report (1991), after considerable reflection, offers: “Risk is the probability that an adverse event occurs during a stated period of time.” Using the term “adverse” at least excludes the notion of risk “gain”. This definition also embraces the concept of containing risk temporally; recognising that any formal treatment of risk should include a time dimension, given that this may affect the likelihood or the impact (or both) of the adverse event. Ren (1994) has also emphasised the importance of a time dimension in risk analysis. Although the Royal Society definition fails to incorporate any explicit reference to the magnitude of the event outcomes, this should not be seen as weakening its meaning of risk. An “adverse event” implies that an identifiable and measurable loss may occur - how otherwise would we know that the event is adverse?

The Royal Society definition is preferred for its conciseness and completeness. It incorporates the three (not two as AS/NZS 3931 states) essential elements of risk: *probability of occurrence*, *potential loss* and *time*.

2.2.2. Risk and uncertainty

A clear distinction between risk and uncertainty is difficult to find in texts on risk analysis or risk management.

Hertz and Thomas (1984) suggest that: "... *risk means uncertainty and the results of uncertainty. ...risk refers to a lack of predictability about problem structure, outcomes or consequences in a decision or planning situation.*"

Cooper and Chapman (1987), in their definition of risk referred to above, also associate risk and uncertainty: "*Risk is ... as a consequence of the uncertainty associated with pursuing a particular course of action.*"

AS/NZS 3931 (1995) notes that uncertainty is connected with risk, and that it may be encountered in the risk data or in the risk models employed for analysis. The Standard advises that it is necessary to translate the uncertainties into risk model parameters.

The OED (1989) provides several contextual definitions of uncertainty: "...*the quality of being uncertain in respect of duration, continuance, occurrence, etc.*"; "...*indeterminate as to magnitude or value.*"; "...*state of not being definitely known.*"; "...*the quality of a business risk which cannot be measured and whose outcome cannot be predicted or insured against.*"

Fine (1982) traces the philosophical shift, for the explanation of phenomena, from religion to science, each with their preference for determinism, and notes that uncertainty has always been an uncomfortable concept for society to deal with. He advocates the use of simulation as a technique for dealing with uncertainty.

Bennett and Ormerod (1984), in the context of construction scheduling, believe that uncertainty is a collection of factors which contribute to construction problems, and is sub-divisible into *variability* in task performance and *interference* in task progress. They note that uncertainty must be dealt with explicitly and systematically if construction management is to be improved.

Mawdesley *et al.* (1997) state that uncertainty is: "...the quality associated with an event which results in an inability to predict its outcome accurately." Their definition supports the notion of unpredictability, but introduces a further concept of accuracy; which would then lead to the question: accuracy in terms of what? Smith (1999) puts it more simply, by associating uncertainty with the "unknown", as compared with the "known", properties of risk.

To summarise the discussion so far, it is reasonable to accept that risk and uncertainty are in some way associated; and that the association may have to do with particular courses of action, risk data, and predictive risk models.

By definition, uncertainty describes some state short of certainty; implying inadequate or incomplete knowledge about the subject at issue. By extension, dealing with uncertainty (eg. in risk analysis) will require some level of *assumption* to substitute for the lack of complete knowledge. It is the level of assumptions which constitute much of the work of risk analysis, flowing on into the decision-making process of risk management.

This assumptive understanding of uncertainty can be illustrated diagrammatically. Imagine a construction situation in which an estimator is investigating the consequences of varying bricklaying productivity upon his or her tender pricing for a construction project, and has recourse to substantial historical case data which permit the objective formulation of a cumulative distribution function for gang outputs.

Figure 2.1 shows a frequency (or probability mass) function for the hypothetical historical case data. For the purposes of the example, it does not matter if these are mean rates taken from different projects or rates observed at random on one or more projects. The estimator has a record of only one case where a bricklaying gang has laid less than 250 bricks per day on a project, and only one case of a laying rate in excess of 800 bricks per day.

While it is theoretically possible that a gang will lay less than 250, or more than 800 bricks per day, by adopting this frequency function the estimator has set *bounds* on the uncertainty associated with the estimating objective. This uncertainty arises because it cannot be known with certainty what laying rate will be achieved if the tender is successful and the project goes ahead. However, by objectively establishing the bounds, the estimator has constrained the uncertainty for the purposes of tender decision-making, and is adopting a frequency approach to probability.

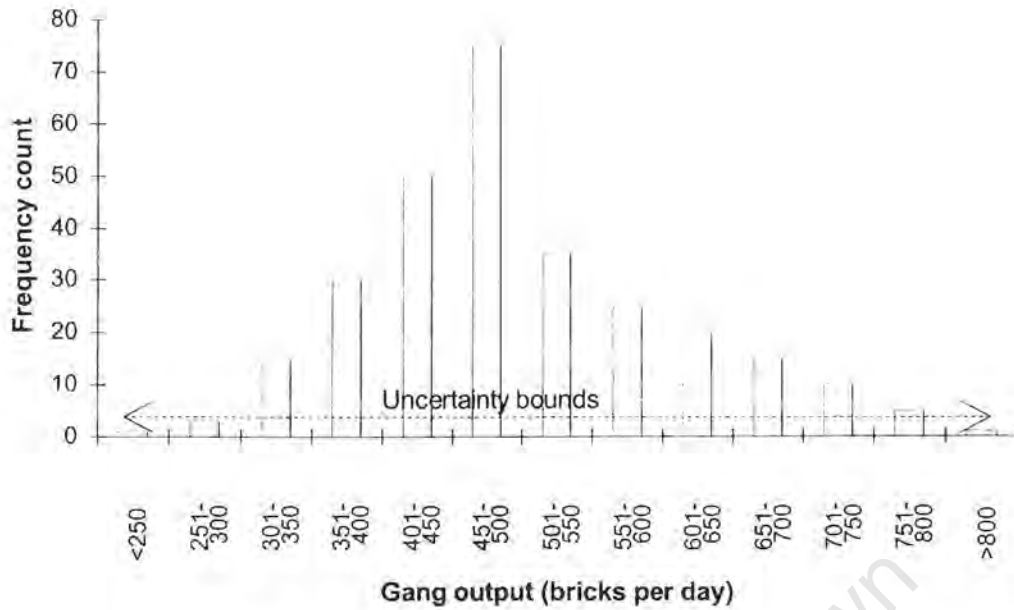


Fig. 2.1. Frequency function for historic bricklaying productivity data.

The hypothetical data may be re-arranged to form a cumulative distribution function, with the frequencies transformed to probabilities (Fig. 2.2).

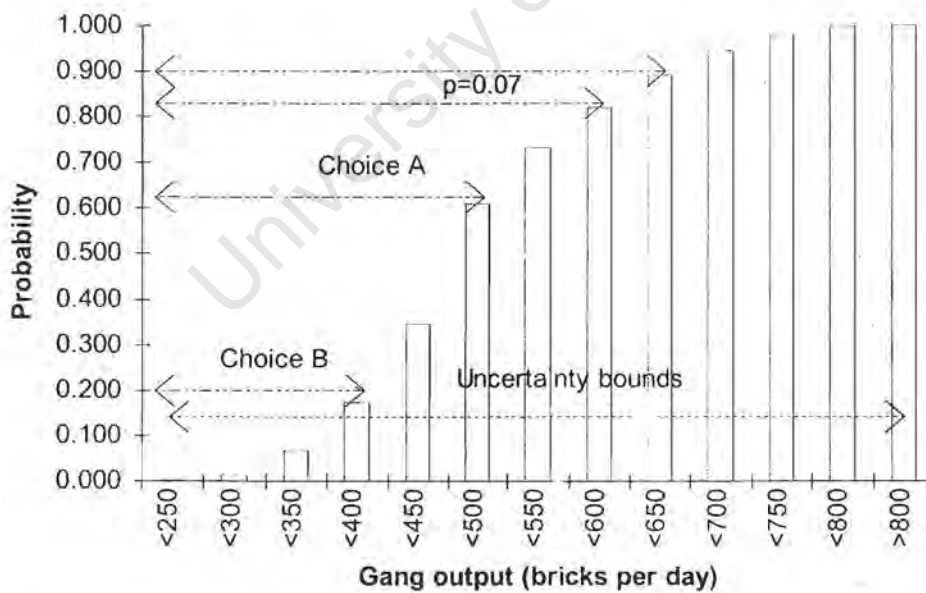


Fig. 2.2. Cumulative distribution function for historic bricklaying productivity data.

The same uncertainty bounds will apply, but now it is possible to explore the probabilities (risks) associated with estimating decisions. Thus, there is a 0.07 (0.89 - 0.82) chance that the

bricklaying rate will lie between 600 and 650 bricks per day. There is just over a 0.6 chance that the laying rate will be less than 500 bricks per day (Choice A: the modal value of Fig.2.1). If the estimator wishes to reduce this risk, Choice B would entail a 0.17 chance that the rate would be less than 400 bricks per day; but then incorporating this more pessimistic rate into the tender would increase the estimated cost of the bricklaying and thus increase the risk that the tender would not be sufficiently competitive to win the job. Basing the tender on higher productivity rates reduces the risk of losing the job, but imposes greater pressure on site management to ensure that the bricklaying gangs achieve the laying rates required for a profitable project outcome. Unforeseen factors may also intervene (the *interference* referred to above) to affect the actual laying rates.

In this example, the uncertainty has to do with particular courses of action (the laying rate decision). It is concerned with risk data intended for use in a risk model. The example serves to show how uncertainty arises; how it is associated with risk; and how it is constrained (or bounded) by assumptions for the purposes of decision-making.

To some extent, this understanding of uncertainty flies in the face of that of Knight (1921, cited in Reutlinger, 1970: 4). Reutlinger takes issue with Knight's contention that events whose probability distributions are known objectively can be labelled as "risks"; while those whose probability distributions are conceived subjectively should be termed "uncertainties". Reutlinger believes that such a distinction is meaningless, given that there can be no "subjective", but only "less objective", estimates. The latter view has been adopted for the conceptual arguments presented here.

Knight's contention, on the other hand, provides the basis for the insurance industry's distinction between risk and uncertainty, where events whose probability of occurrence and impact can be statistically assessed are treated as *insurable risks*; while events where this cannot be done are treated as uncertainties and uninsurable. However, this is simply a distinction made for the purpose of commercial decision-making, and should not influence the search for a more profound distinction.

It may also be argued that, in real life, the mass of objective data hypothesised for the bricklaying example is unlikely to be available, and therefore the process of bounding the uncertainty is impossible. Certainly the task becomes more difficult, but it can be done. In his essay on uncertainty as a philosophical problem, Gallie (1957) expands on the economic expectation theories of Shackle (1952), and concurs that it is rationally defensible to treat the irreducible

uncertainty of virtually unique or non-seriable decisions in economics, not in terms of traditional probabilities but in terms of the capacity of the outcomes to *surprise*. Thus, an experienced estimator might be surprised if bricklayers were to achieve a rate of less than w or more than x bricks per day, and highly surprised if their rate was less than y or more than z bricks per day. We can bound the uncertainty by the degree of surprise we are prepared to experience. The element of human judgement is brought into play, and is conditioned by the presence of human biases (Birnie, 1993). In the surprise approach to uncertainty lies the germination of fuzzy set theory as a means of “calculating” uncertainty through a mathematical treatment of linguistics (Zadeh, 1978; Kangari and Riggs, 1989; Mak and Wong, 1997).

Uncertainty, then, is distinguishable from risk. True uncertainty is converted to bounded uncertainty by assumption, based on judgement, for the purposes of risk analysis. For effective risk management this must be followed by risk response and translated into the control and review mechanisms of construction and project management.

2.2.3. Risk analysis (risk engineering)

Hertz and Thomas (1984), in demonstrating risk analysis through case histories, state that it is: “...the application of methods which aim to develop a comprehensive understanding and awareness of the risk associated with a particular variable of interest.”

The OED (1989) defines risk analysis as: “...the systematic investigation and forecasting of risk in business and commerce”; and goes on to describe this process as: “...the translation of the judgements of financiers, engineers, etc. into the language of probability”, suggesting that: “risk analysis helps a manager make reasonable decisions”.

AS/NZS 3931 (1995) refers to risk analysis as: “...the systematic use of available information to identify hazards and to estimate the risk to individuals or populations, property or the environment.”; while AS/NZS 4360 (1995) defines it as: “...a systematic use of available information to determine how often specified events may occur and the magnitude of their likely consequences”.

Chapman (1994) notes that: “Formalising risk analysis puts a risk manager in control of events instead of relying wholly on intuition or experience”. Although this view places risk analysis and risk management on an analogous footing, it is the concept of analytical formality which is important here.

Risk analysis is therefore an investigative process which deals with quantitative aspects of specific risks associated with a particular endeavour. The term “quantitative” in this instance should be interpreted to include both numeric and qualitatively linguistic approaches to analysis. The process is carried out systematically in terms of establishing probabilities of occurrence and magnitude of outcomes. Much of the extant literature (eg. Smith, 1999; Verzuh, 1999) ignores the essential time component of risk, and this omission oversimplifies the potential problems of risk analysis. Smith (1999), for example, in discussing risk decision-making, presents a simplistic two-dimensional view of probability and impact (See Fig.2.3).

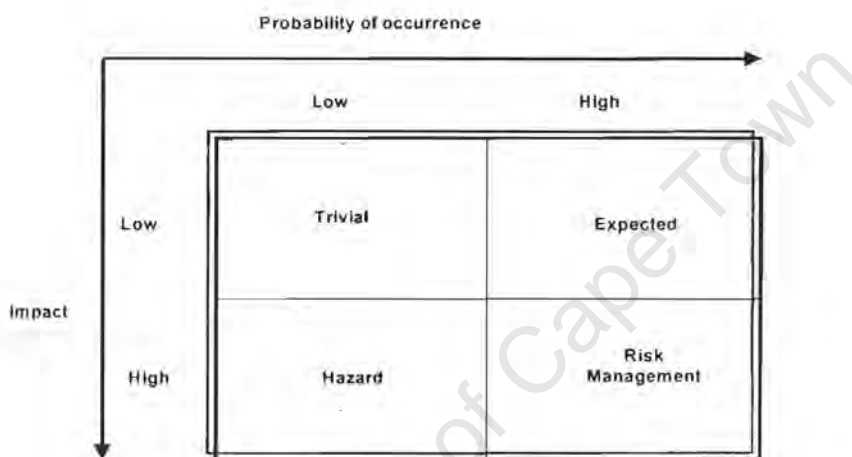


Fig. 2.3. Classification of risk sources [sic.] (Source: Smith, 1999)

The label of this figure should probably have read "magnitudes", rather than "sources", but it is its simplicity which is misleading. Complexity appears immediately when the time dimension of risk is included, and further complexity is added if the linguistic scales for probability and impact are expanded, as shown in Fig. 2.4. The expanded scales are based on those proposed in AS/NZS Standard 4360 (1995), where "low", "medium" and "high" are used for the impact scale. For the probability scale, the following descriptors are taken from the Standard:

- **Rare:** exceptional circumstances
- **Unlikely:** could occur at some time
- **Moderate:** should occur at some time
- **Likely:** will probably occur
- **Almost certain:** expected to occur

Intervals on the time scale (short-term; medium-term and long-term), would have to be defined more precisely in terms of the risk-taker's corporate strategy, as would the impact descriptors. Even this diagram does not fully represent the potential complexity of risk analysis, as the dynamic nature of some risks has been ignored. Reference was made in Chapter 1 to the dynamic property of risk; where probability and magnitude of outcome may not necessarily be fixed in or over time. It was noted that the probability of occurrence for some risks may increase or decrease with the passing of time; as may their impacts. Some risks may be associated with a single event on a single occasion. Others may occur repeatedly on repeated occasions. This dynamic complexity is difficult to render graphically, but it does exist and cannot be ignored in risk analysis. Ward (1999) refers to it in the context of the "urgency" of risk management.

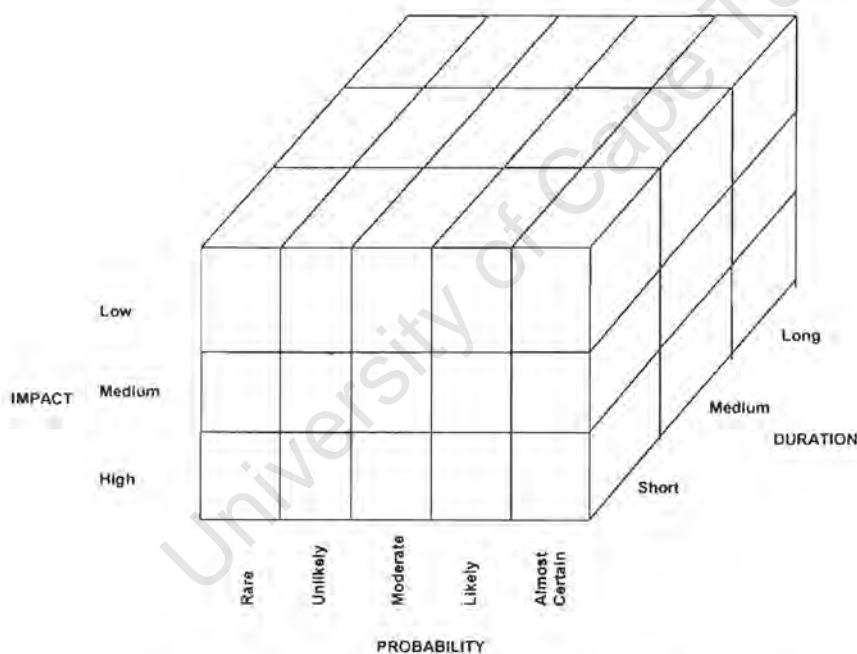


Fig. 2.4. Three-dimensional complexity of risk analysis.

As will be seen from the following discussion, risk analysis is an essential component of risk management. Conversely, however, risk management is not essential to risk analysis, which could simply comprise an academic exploration of risk without entailing subsequent decision.

Lifson and Shaifer (1982) distinguish between risk analysis (as the process of dealing with uncertainties as part of the estimation of the probabilities associated with a risk event) and risk

evaluation (the calculation of the potential impact), but this is probably an over-fine separation of assessment activities.

Some authors (eg. Cooper and Chapman, 1987; Chapman, 1990) regard risk analysis and risk engineering as synonymous with risk management. This synonymity view could endanger a full understanding of the broader psychological and sociological dimensions of risk and risk management, although Cooper and Chapman (1987) are careful to point out that: “...a risk engineering approach need not be about measuring risk, and need not use probabilities: as an aid in developing and communicating risk...structured verbal models can be useful...”.

Risk engineering, as a term analogous to risk analysis and risk management, is really an unnecessary distraction. While it might be argued that “engineering”, in the context of construction, might have a useful connotation of management of design to mitigate risk, such contextual narrowness is undesirable from a management point of view. The same argument would, for example, produce a tautology in the term “engineering management.”

The notion of structured verbal models for risk analysis to some extent ties in with the graphic portrayal of risk complexity shown in Fig. 2.4, which could assist in choosing a level or type of analysis to be used in any particular risk situation.

A similar approach can be developed, using Smith's (1999) "known/unknown" concept of risk and uncertainty. By incorporating the time component, an uncertainty matrix can be drawn (Table 2.1).

<u>Probability</u>	<u>Impact</u>	<u>Duration</u>	<u>Technique</u>
Known	Known	Known	Formal probability
Known	Known	Unknown	Ditto + sensitivity
Unknown	Known	Known	Ditto + sensitivity
Known	Unknown	Known	Ditto + sensitivity
Known	Unknown	Unknown	Simulation
Unknown	Unknown	Known	Simulation
Unknown	Known	Unknown	Simulation
Unknown	Unknown	Unknown	Scenario tests

Table 2.1. Risk uncertainty matrix.

It should be possible to draw guidance from the matrix about the appropriate analytical tool(s) to be used for analysing any risk. Where all the risk dimensions are known, formal mathematical probability analysis should be possible. Where one dimension is unknown, mathematical analysis with sensitivity testing may be appropriate. For two unknown dimensions, simulation (eg. Monte Carlo simulation) could be applied; while for three unknown dimensions scenario testing might be the only analytical approach possible. Bounding the uncertainties might be achieved with Delphi analysis; while qualitative linguistic variables may require the application of fuzzy set theory. As noted in Chapter 1, this research is not primarily concerned with the formal quantitative treatment of risk, except insofar as this may influence the perceptions and actions of project participants, and the techniques of risk analysis are therefore not pursued in further detail. The risk uncertainty matrix of Table. 2.1 is simply a conceptual proposal which illustrates the need to select appropriate analytical techniques, and is not tested further in this research.

In summary, risk analysis is the systematic assessment of decision variables which are subject to risk and uncertainty. The risk analysis process comprises the quantitative or qualitative establishment of probabilities of occurrence of adverse events; the measurement of the impact of event outcomes over considered periods of time; and the setting of assumptive bounds to associated uncertainties. The process first requires that the risks be identified. The words of a contributor to discussion at a conference on risk management in civil, mechanical and structural engineering, held in London in 1995, provide a succinct overview:

"...risk assessment [analysis] doesn't give you the answer, it helps you understand the problem...it helps you understand the importance you attach to things."

(James, 1996: p46)

2.2.4. Risk management

Risk management implies a deliberate attempt to deal with risk. For the Royal Society (1991):

"At the most general level, the process of risk management can be understood in terms of the three basic elements of organisational control theory... : the setting of goals, whether explicitly or implicitly; the gathering and interpretation of information; and action to influence human behaviour..."

Hayes *et al.* (1986) and Raftery (1994a) take a "task" view of project risk management as a process involving risk identification, risk analysis, and risk response. Flanagan and Norman (1993), while sharing this approach, identify an additional stage as well as an exogenous

influencing factor. Their sequence includes risk identification; *risk classification*; risk analysis; *risk attitude*; and risk response. The stage of risk classification is really an extension of risk identification. The inclusion of risk attitude in the sequence is more questionable. It is certainly not a *task* of risk management, which Flanagan and Norman acknowledge implicitly in their diagrammatic representation by off-setting it from the main sequence of tasks. However, nor is it a factor which need only be considered at the risk response stage of risk management. Risk attitude (in terms an individual's or an organisation's degree of aversion to risk) permeates the whole of risk management.

AS/NZS 3931 (1995) describes risk management as: "*The systematic application of management policies, procedures and practices to the task of analysing, evaluating and controlling risk.*" This task approach combines risk assessment (comprising risk analysis and risk evaluation) with risk reduction/control to form risk management. The definition proposed in AS/NZS 4360 (1995) is identical except for "... *to the tasks of identifying, analysing, assessing, treating and monitoring risk.*" The latter Standard also emphasises the importance of establishing an appropriate context for risk management: strategic, organisational, or management.

From the above discussion, risk management can be defined more simply as: *a systematic approach to dealing with risk.*

Procedurally, a risk management system should: *establish an appropriate context; set goals and objectives; identify and analyse risks; influence risk decision-making (ie. risk response); and monitor and review risk responses.*

Just as risk attitude permeates risk management, so should risk management itself permeate the whole of project and construction management, and their associated sub-fields of financial, quality, value and occupational health and safety management. Indeed, it should flow temporally on into the operational management of the completed project, and eventually also into the management of its final disposal.

The project management theories of Walker (1996) are useful in setting an appropriate context for project and construction risk management, and the conceptual model shown in Fig. 2.5 is adapted from his work, which focussed on the procurement of projects. This is further elaborated in Fig. 2.6, where risk management is placed in the context of project decision-making, always remembering the presence of the over-lapping contexts of behavioural responses, organisation structure, and techniques and technology. The objectives of project and construction risk

management should, however, be clearly established within the context of project decision-making, and will be governed largely by the risk attitude of the project proponent.

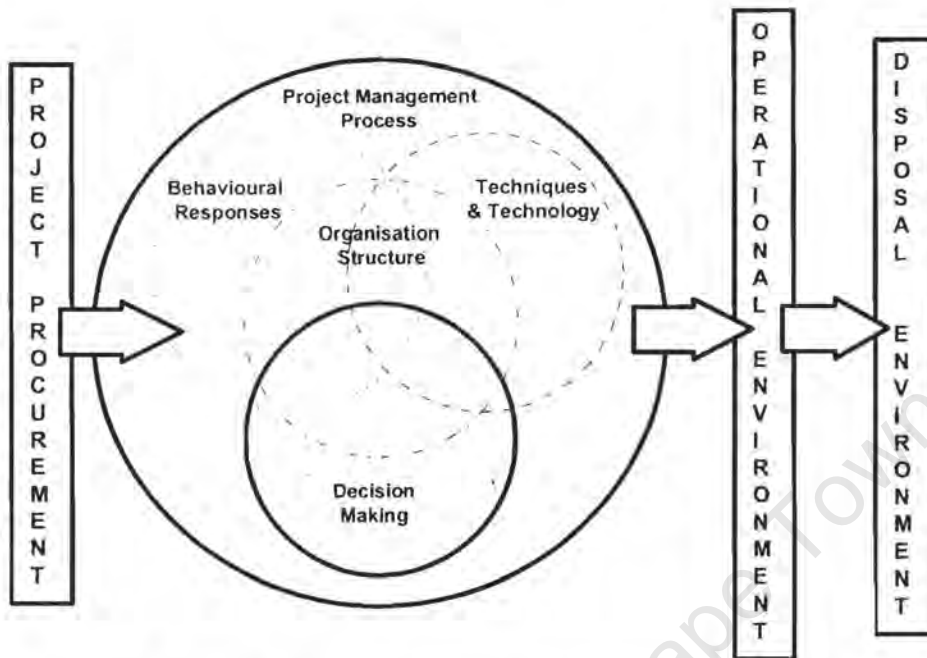


Fig. 2.5. Contexts for construction project management (adapted from Walker, 1996).

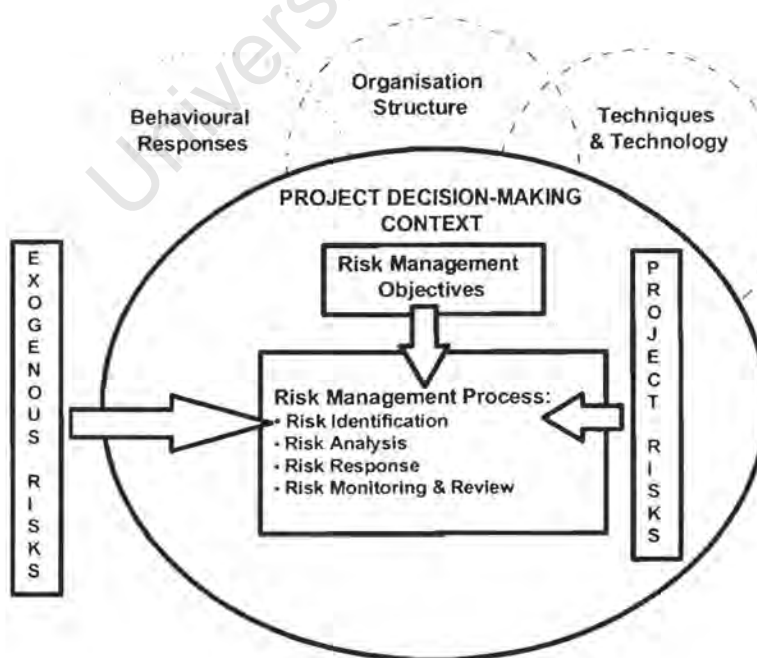


Fig. 2.6. Conceptual model of construction project risk management.

Walker's (1996) contextual view is supported by Raftery (1994b) who, in discussing human judgements in decision-making, proposes a sociological and organisational context for risk analysis.

2.2.5. Summary

This section has provided a broad definitional basis for exploring project and construction risk. Risk is defined as: the probability that an adverse event occurs during a stated period of time. Uncertainty is associated with risk in terms of the lack of complete knowledge surrounding the occurrence and/or impact of adverse events. Risk analysis is the systematic assessment of decision variables which are subject to risk and uncertainty. Risk management is a systematic approach to dealing with risk which establishes an appropriate context; sets goals and objectives; identifies and analyses risks; influences risk decision-making; and monitors and reviews risks during the progress of a project.

The tasks of identifying, analysing and responding to project and construction risks is helped considerably by the ability to consider *types* of risks; ie. categories in which particular risks might be placed. The following section discusses this aspect of risk management.

2.3. Risk categorisation.

The Royal Society (1991) identifies three "conventional" types of risk explored in academic research: natural hazards; technological hazards; and social hazards. Two further types are noted: health hazards and financial risk (Royal Society, 1991), with the *caveat* that distinctions between all types of risk cannot be absolute because of cultural differences which may cause one group to perceive a hazard as natural which another group might regard as social or technological.

In the Royal Society (1991) report, *natural* hazards are defined as those occurring outside human systems or agencies. Examples would include earthquakes and hurricanes. Hazards of *technology* occur within human-designed systems, and would include events such as collisions between ships or vehicles; explosions; fires attributable to electrical equipment failure; and failure of structures. *Social* hazards arise from human behaviours such as arson and sabotage. *Health* risks would relate to epidemics and surgery.

Cooper and Chapman (1987) initially offer two risk categories: natural and structural; but then proceed to add two more: construction/maintenance, and postulated. Structural risks are really design error risks, and, as will be seen later, could be categorised as *technical* risks. Construction and component maintenance risks could, depending on their cause, be categorised as either *technical* or *managerial* risks. “Postulated risks”, according to Cooper and Chapman (1987), include events such as collision, vandalism, and sabotage. In terms of the categories proposed later in this paper, the former would be a *technical* risk, while the latter two would be considered as *social* risks.

In the context of early decision-making for major (“mega”) projects, Chicken (1994) proposes three major categories of risk: technical; economic; and socio-political. He argues that any assessment must be based on all of these. Further, he believes that the risk assessments should be transparent to the project proposer (and to the lay public where relevant), and that the assessment processes should have a logically defensible structure.

AS/NZS 3931 (1995) includes four risk categories: natural; technological; social; and lifestyle, but suggests that other categorical systems may be auspicated in terms of the *consequences* of risk, such as individual; occupational; societal; property/economic; and environmental. AS/NZS 4360 (1995) suggests lists of generic sources of risk rather than categories. It provides an initial list of eight sources including: commercial and legal; economic circumstances; human behaviour; natural events; political circumstances; technology; management activity; and individual activities. However, the Standard then proceeds to identify a second list of thirteen types of risk: disease; economic peril; environmental; financial; human; natural; occupational health and safety; product liability; professional liability; property damage; public liability; security; and technology. There are obvious duplications in the two lists, and neither shows evidence of any underlying rationale.

Life-cycle application phases are suggested in AS/NZS 3931 (1995) as another approach to categorising risk. The phases are identified as: concept and definition phase; design development phase; construction, production, transportation, operational and maintenance phase; and the disposal phase. Little obvious advantage accrues from this as a primary categorisation approach, although for specific projects it might serve to provide a clearer focus for the time component of risk.

The obvious problem in attempting to categorise risk, apart from the cultural perceptions noted by the Royal Society report, is that there is a danger of confusing sources, causes, effects and fields

of study for the risk domains. The two Australia/New Zealand Standards serve to illustrate this, but the confusion may also arise from consideration of individual risk circumstances. For example, the impact of a hurricane may be aggravated in an environment which has been degraded by over-grazing or deforestation, but essentially the hurricane risk is still a natural one in terms of its source. While adverse soil conditions are a perennial risk for construction, this risk is also a natural, albeit latent, one. The potential for risk is simply activated by the decision to construct. Yet again, the damaging effects of a soil washaway may be increased by the removal of natural water-courses through bulk earthworks excavations, but the source of the risk is still the storm which precipitated the washaway. These examples suggest that it is one or more of the elements of risk - probability, loss and time - which may be affected by changing circumstances, not the type of risk itself.

The *source* of the adverse event may therefore be the best primary denominator (Hayes *et al.*, 1986; Chapman, 1994); in which case just two basic categories should suffice: *natural* and *human*, since all technological (system) risks (Royal Society, 1991) must stem from some form of human activity. From this starting point, sub-categories can be developed for different risk domains. A source approach to risk categorisation is proposed diagrammatically in Fig. 2.7, using a systems context. The sub-categories of natural risks are weather systems, geological systems and extra-terrestrial systems; while those for human risks comprise social; political; cultural; health; legal; economic; financial; technical and managerial systems.

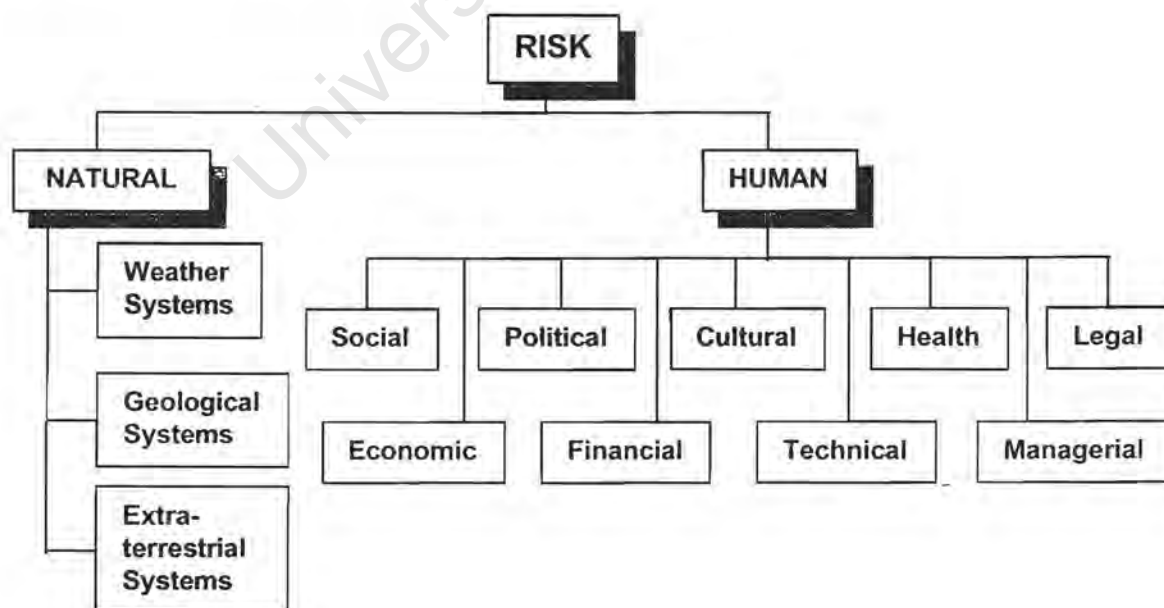


Fig. 2.7. Systems-based risk source categories.

2.3.1. *Natural risks*

As noted earlier, natural risks (ie. risks occurring outside human agencies) arise from systems whose existence is beyond human device. These may be found on or beyond the planet Earth. Terrestrial weather systems, for example, are responsible for risks such as hurricanes, typhoons, tornadoes, floods, tidal waves and lightning strikes. Geological systems give rise to risks of earthquakes, volcanic eruption, and geological faults. A meteorite shower is an example of an extra-terrestrial natural risk. However, a potential collision between earth and man-made space debris, caused by the latter falling from its orbit, would be regarded as a human risk, in the technical category.

2.3.2. *Human risks*

Risks arising out of human agencies are more difficult to categorise than natural risks, due largely to the overlapping characteristics of many humanly-devised systems. Nevertheless, it is possible to indicate examples of human systems risks.

Behaviour which is unacceptable to society generally may be categorised as *social risk*. It may include criminal acts such as theft, robbery, assault and murder, sabotage, arson and espionage; civil torts such as trespass, slander or libel; or substance abuse such as alcoholism and other drug-induced behaviour. Graffiti might also be classified as a social risk, but it is important to remember that it is the values set by society which determine what behaviours are anti-social. These values may be culturally-determined, and may change substantially over time.

Risks arising out of government action may be classified as *political risks*. Among these, war and foreign treaties are straightforward examples. Political risks may also arise from opposition to government threat or action; for example in cases of civil disorder or industrial action.

Cultural risks emanate from potentially negative interactions between different cultural or religious systems. At a government level, of course, such risks are treated politically, but this does not change their source.

Risks arising from surgery or epidemia may be categorised as *health risks*.

In the *legal* category of risk would be found matters relating to commercial and private contracts and agreements; as well as other legally-enforceable instruments such as statutes, regulations and codes. It should be noted that, at the drafting stage of such instruments, they should be regarded as political risks.

It is not easy to make a clear distinction between *economic* and *financial* risk categories and, for much of project and construction risk management, to do so may be unnecessary. One approach, however, may be to distinguish physical factors of production from factors affecting the cost of finance or security of cash flows. Thus, examples of economic risk might include labour or material supply issues; while changes in interest rates or credit ratings would be regarded as financial risks.

The *technical* category of risk involves situations where failure of some humanly-designed technical system is likely to occur. Examples range from equipment breakdown to collision and accident. While it is easy to understand the former, the inclusion of the latter two in this category may be more difficult to accept. Given that there is no deliberate human intent or presence of substance abuse (which would place them in the social risk category), then collisions and accidents can more properly be seen as a failure (or absence) of technical systems to prevent them.

Managerial risks relate to situations where adverse events occur which are due solely to some failure of management to take appropriate action to avoid them. Examples include poor productivity or excessive wastage by workers. Occupational health and safety risks may also be included under this category.

2.3.3. Summary

This section has explored a means of categorising risk by source. Two primary source categories, natural and human, have been identified, together with further sub-categories of these.

In the main, allocating risks to a particular category source is best done from the point of view of the organisation on whose behalf the risk management activity is being undertaken. This brings the *locus* for risk response more directly into focus. In the interest rate example above, treating the possible occurrence of high interest rates as a *financial* risk for the organisation allows a more focussed approach to alternative response strategies than would the more abstract category of *economic* inflation. However, the niceties of fine-tuning risk categories should not be allowed to occur at the expense of the benefit-to-cost ratio of the risk management process itself.

From this categorical understanding of risk, it is possible to explore the nature of project and construction risks.

2.4. Project risks and construction risks.

Carr (1977) notes that client (project) risks are broader than, but include, construction risks, and arise out of the procurement method adopted for the project. In the main, these project risks are associated with the time, cost and quality objectives of projects. Carr suggests that contractors perceive risks primarily as associated with delays occasioned by adverse weather, client-initiated changes, materials and labour supply or price changes, incorrect estimates, and subcontractor issues. He theorises that, in terms of a utility theory approach, clients and contractors are likely to value these risks differently (Carr, 1977).

Bennett and Ormerod (1984) provide a list of unknown possibilities (risks) which constitute problems for construction managers. Their list includes: actions of external agencies; unknown or unassessed elements of work to be performed; errors and omissions in working drawings; delays in obtaining approvals; adverse weather; late delivery of materials or equipment; unknown results of testing and commissioning services installations; inflation; variable performance work rates; mechanical breakdowns; and re-work.

Similar risk sources are identified by Hayes *et al.* (1986), who take a project view. Factors additional to those indicated above include: changes in local regulations; uncertainty of project manager status; local custom; contractor experience and financial stability; excessive wastage of materials; industrial relations; site access and remoteness; exchange rates; and *force majeure*.

Wideman (1986) adopts a categorisation approach (external unpredictable; external predictable but uncertain; internal non-technical; technical and legal) which lacks the rigour of that proposed in Fig. 2.7, and tends to confuse sources and impacts, but he introduces additional specific risks such as quality, licences and patent rights.

Al-Bahar and Crandall (1990) advocate a checklist approach to risk identification and categorisation for construction projects, with categories similar to those of Fig. 2.7 but less generic (eg. *design* is afforded a category group of its own rather than being treated as a technically-sourced risk). However, they do identify several political risks, and amplify the number of natural risks. Edwards (1995) looks at risk identification from the separate viewpoints of clients, contractors and consultants.

Synthesising all these views on project and construction risks, it is possible to relate them to the risk source categories shown in Fig. 2.7, and this is proposed in Fig. 2.8. The list of risks shown is not exhaustive, but even so some potential for overlaps can be detected. Cultural risks, for example, arising out of a trans-national company's construction activities in a foreign country, might also be

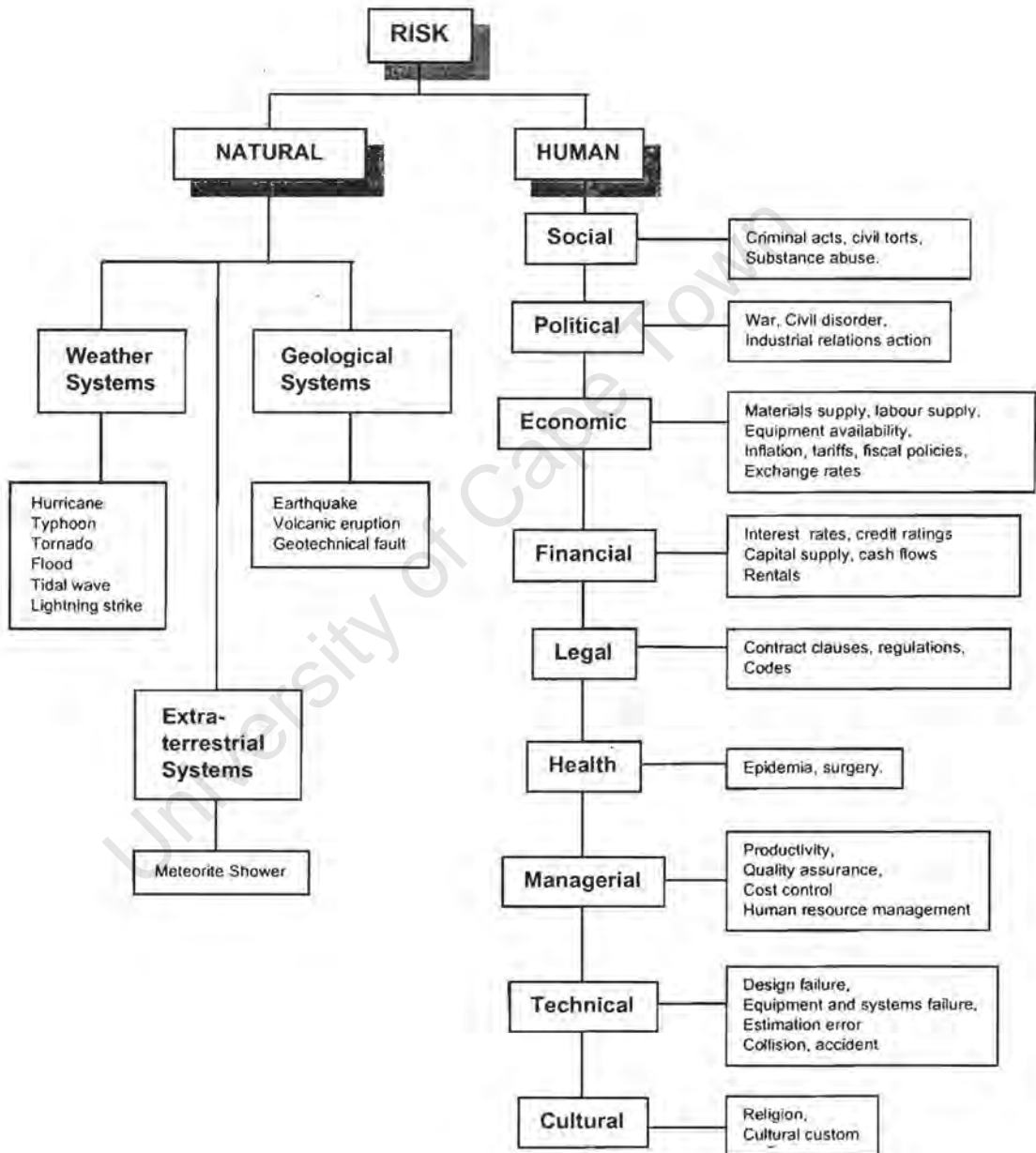


Fig. 2.8. Categorised project and construction risks.

considered as human resource management risks in the *managerial* category. Similarly, high interest rates, as a *financial* risk, may occur as a deliberate monetary policy intervention of

government to deal with rising inflation in an economy, and thus more properly be regarded as an *economic* (or even *political*) risk.

2.4.1. Summary

The categorisation of project and construction risks is useful for the processes of risk management. It helps in the identification of risks likely to be encountered, and may also point towards some commonality of treatment in terms of analytical techniques, response, or monitoring and review systems. This section has shown how construction and project risks can be classified within more generic risk categories and sub-categories, without having to resort to devising special or unique classifications.

2.5. Conclusions.

Construction professionals should aim to achieve a better understanding of the place of risk in the formal decision-making processes relating to projects. To this end, concepts relating to risk, uncertainty, risk analysis and risk management in the construction industry have been explored and the terminology has been clarified.

“Risk” is the *chance (probability) that an adverse event occurs during a stated period of time.*

“Uncertainty” is distinguished from, but associated with risk, and is *a state of incomplete knowledge about a decision variable.* For the purposes of risk analysis, the uncertainty surrounding a variable may be bounded by assumptions based upon human judgement.

“Risk analysis” is the *process of assessing decision variables which are subject to risk and uncertainty,* and comprises the identification of risks; the establishment of probabilities of occurrence; the setting of assumptive bounds to associated uncertainties; and the measurement of the impact of event outcomes.

“Risk management” is *a systematic approach to dealing with risk.* It should take place within an appropriate context (usually that of project decision-making), with specific goals and objectives. The risk management process will identify and analyse risks; influence risk decision-making; and monitor and review risk responses.

Risks may be categorised by their *source*. The two main categories are “natural” risks, occurring outside human agencies; and “human” risks, arising as a consequence of human systems or actions. Sub-categories of human risks include social, political, cultural, health, legal, economic, financial, technical and managerial sources of risks. All project and construction risks, other than those arising from natural sources, may be assigned to one or other of these sub-categories.

This chapter, comprising a conceptual and definitional review of risk and risk management, together with a categorisation of risks in terms of their source, provides the necessary basis for a review (which follows in Chapter 3) of the extant research into project and construction risk and risk management.

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University of Cape Town

CHAPTER 3

CONSTRUCTION AND PROJECT RISK AND RISK MANAGEMENT

3.1. Introduction.

In this chapter, an analytical review of the construction risk literature over the period 1960-2000 is presented. The chapter uses the definitional discussions and risk categorisation proposals developed in Chapter 2 as the basis for a temporal and epistemological review which examines construction and project risk knowledge from three viewpoints: analytical applications in construction; the development of a systematic approach to project/construction risk management; and the emergence of a “soft systems” risk management view. The purpose of this chapter is partly to validate the research problem stated in Chapter 1, and partly to provide a clearer focus for the research design proposed in Chapters 5 and 7. It addresses the subsidiary questions: *What are project and construction risks?* and *What has other research in this field revealed?*

3.2. Analytical review of risk literature (1960-2000).

The themed temporal approach to the literature analysis has been applied to more than three hundred and fifty written articles and texts appearing in authoritative English-language publications, over the period 1960-2000. Some limitations must be noted. Firstly, material on the pure mathematics of risk has been excluded, partly on the grounds of its antiquity, but also because it is not germane to this research study. Secondly, no attempt has been made to exhaust the extensive literature of decision theory itself, with respect to basic research in human decision-making. Nor has any of the literature of communication theory been included. A broad but shallow review of these topics is included in Chapter 4. It is the extent to which they have spilled over into the construction and project management literature that is of interest in this chapter. Finally, the publications were sourced mainly as journal articles, conference proceedings and books dealing with project and construction management, and building procurement, published during the period 1960-2000. While earlier publications may include some reference to risk and uncertainty in construction, 1960 marks the point where substantive treatments of the topic first begin to appear in English-language construction publications, and provides a starting point for the five-yearly interval groups of the temporal analysis.

3.3. Temporal analysis.

The results of the temporal analysis are shown diagrammatically in Figure 3.1.

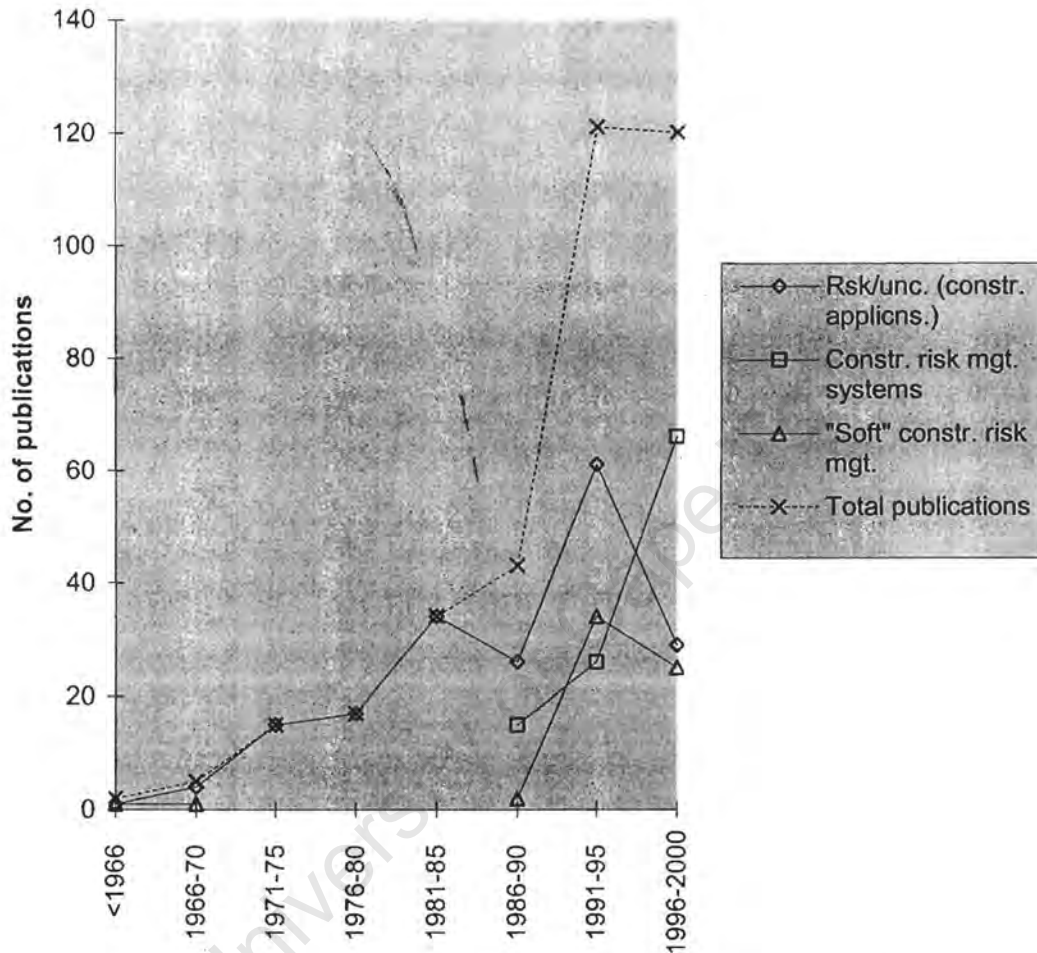


Fig. 3.1. Construction and project risk publications (1960-2000)

Five-yearly intervals, subsequent to 1965, were adopted in order to provide adequate definition to the graphic display, and coherent periods for analysis.

The diagram reveals several interesting points. Firstly, applications of quantitative theories and techniques to construction progress slowly at first, but accelerate rapidly over the twenty-year period from 1976-1995.

Secondly, some twenty years after the applied construction risk research has commenced and is entering its most prolific phase, systems theory becomes a popular vehicle for the development of construction risk management, with a growth rate of research publication almost matching that of

the applied research. The adoption of a systems approach to construction risk management occurs about fifteen years after the birth of systems theory itself in the early 1970's.

Finally, interest in a "soft systems" approach (not so labelled until some years later) to risk management makes a modest start at about the same time as the applications phase, but accelerates rapidly in response to the development of "soft systems" theory (Checkland and Scholes, 1990).

The trend lines for 1996-2000 in Figure 3.1 cannot be regarded as definitive as the period is not complete (lacking one half-year). However, inspection of the relative annual rates of publication (see Figure 3.2) suggests that applied research into construction risk applications has peaked and is declining quite sharply. Construction and project risk management systems research is continuing to be published at an increasing rate. This was overtaken by "soft systems" risk management research publications for a few years prior to 1996, but the latter now appear to have settled to a slightly lower rate. The decline in the risk applications publication rate has adversely affected the overall annual publication rate since 1995, but nevertheless the overall publication rate has not yet peaked. Clearly, however, the decade 1986 – 1995 was the "golden age" for construction risk and risk management research and publication.

The decline in publication rates for construction applications of risk and uncertainty, and for "soft systems" risk management, coupled with the acceleration in the publication rate for risk management systems, is disturbing, and suggests that a substantial shift in the type of risk research is needed. Inspection of very recent publications dealing with risk management systems *per se* shows that few are adding substantially to the body of knowledge on this topic. Several publications simply repeat descriptively the by now well-known processes of risk management. If the authors' are aiming to achieve a wider dissemination of risk management knowledge within the construction industry, this would be better undertaken through industry-based, rather than research-based, publications. For the latter, it is knowledge of specific risks, the ways in which they are perceived, and the manner in which risk decisions are made, which is now required. We need to explore how effective risk management systems are in practice.

In terms of the literature sources, the early period (1960-1980) is dominated by works published in the *Journal of the Construction Division* of the American Society of Civil Engineers. Since 1981 the publication frequency honours have been shared between the *Journal of Construction Management and Economics* and the *International Journal of Project Management*, both United Kingdom journals. However, this should not be seen conclusively as a geographical shift in the

research effort. Evidence from the content of the publications suggests that some of the early UK research work, particularly in the area of risk analysis applications to construction simply lagged, by ten to fifteen years, that previously published in the American journals. On the other hand, publication of “soft systems” approaches to construction risk research has been the almost exclusive preserve of UK journals over the whole review period.

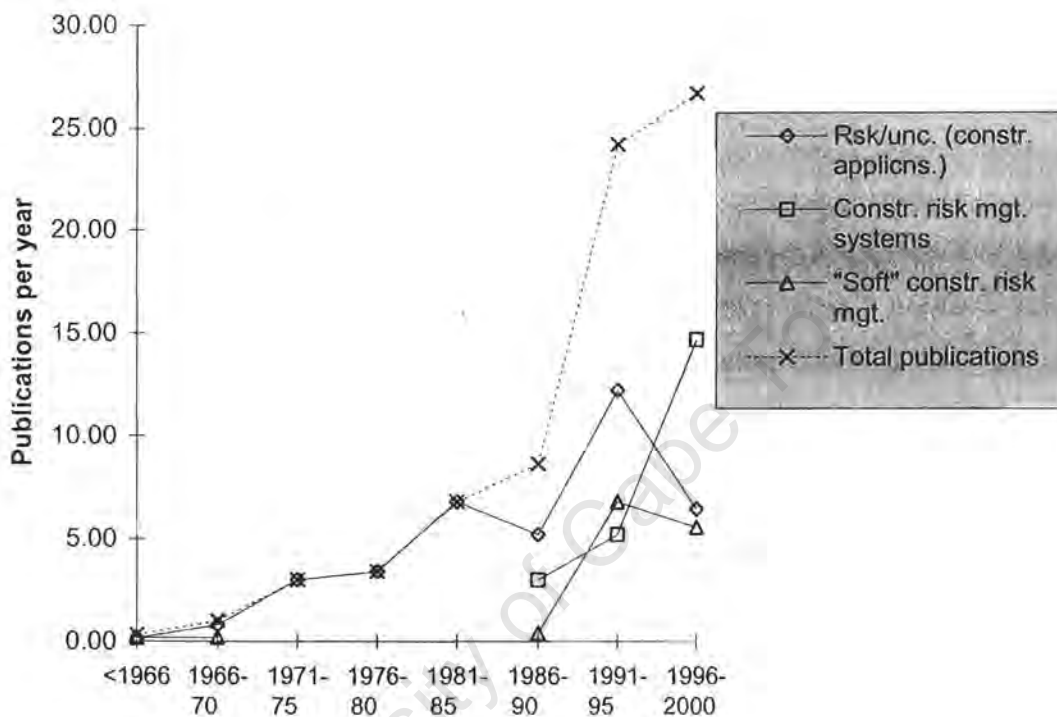


Fig. 3.2. Annual publication rates (1960-2000)

Contributions from the CIB (*Conseil International du Bâtiment* - the International Council for Building Studies and Documentation) began to occur with the proceedings of the second W65 symposium (Organisation and Management of Construction) in 1978. Since then they are regularly to be found in the subsequent symposia of the W65 (Construction Management), W55 (Building Economics) and W92 (Procurement Systems) Working Commissions of CIB.

Texts about project and construction risk include authors such as Pouliquen (1970), Reutlinger (1970), Lifson and Schaifer (1982) and Marshall (1991) in the USA. In the UK these are followed by Beeston (1983), Hertz and Thomas (1983, 1984), Hayes *et al.* (1986), Cooper and Chapman (1987), Murdoch and Hughes (1991), Flanagan and Norman (1993), Chicken (1994), Raftery (1994a), Edwards (1995), Chapman and Ward (1997) and Smith (1999). Byrne and Cadman (1984) and Byrne (1996, in a revised version of the same text) have written about risk and

uncertainty in the context of property development. Many texts on project and construction management include chapters devoted to risk management, usually written from a quantitative risk analysis point of view (eg. Walker, 1996).

Given this overall temporal view of construction and project risk research, it is now possible to examine the research literature thematically. To make individual reference to each of the journal articles, conference papers and texts reviewed (more than 350 publications) would be impractical and unnecessary in the context of the objectives of this chapter. Only the earliest papers on the themes, or the material thought to be the most important, are discussed.

3.4. Applications to construction.

In order to give contextual relevance to the review of the literature on applications of risk analysis to construction, the risk source categories proposed in Chapter 2 (and illustrated in Fig. 2.8) are used as a basis for discussion.

3.4.1. Social risks

Social risks involving criminal acts (eg. sabotage, arson) on construction projects have attracted no detectable research interest to date. There is little in the literature other than a reference (as a “postulated” risk) in Cooper and Chapman (1987). These risks, and civil torts such as trespass, damage to fences, unauthorised graffiti and similar acts of vandalism, are likely to become a more frequent occurrence on projects in the wake of the growth of militant protest lobby groups, particularly in Western societies, and this area is under-researched in terms of risk. While the examples given are more likely to result in the project proponent appearing as plaintiff, or as witness for the prosecution; they can also lead to risks of counter-claims by the perpetrators of the risk trigger acts.

The nature, incidence and impact of substance abuse on construction sites are becoming topics of interest for occupational health and safety research (Eilenberg and Coble, 1996). However, there is no evidence to show that this is being done from a risk management point of view.

3.4.2. Political risks

By 1987, *political* risk in construction projects had become a topic for debate (Ashley and Bonner, 1987). Their paper defines political risk as foreign government interference with the

normal conduct of business, and was written mainly in the context of multi-national construction firms and developers operating in foreign countries; but, as noted in Chapter 2, political risk could also arise from actions of the organisation's home government against other countries (eg. trade embargoes), or from action within the home country (eg. statutory amendments being made to industrial relations legislation after a change in government). Chicken (1994) describes social and political risks as "soft" factors in risk management for major projects, largely because of the difficulty of dealing with them quantitatively.

3.4.3. Economic and financial risks

The prevailing spectre of inflation in the late 1970's and early 1980's prompted Warszawski (1981) to consider its risk implications for construction cost control, profit planning and other managerial decision-making for construction projects. This is a rare contribution to the *economic* category of the construction risk literature. Another surprising rarity is *financial* risk in construction projects, which appears to have attracted far less attention, from a risk research point of view, than might be expected, given its importance to project feasibility. Bowen (1984b), in a hypothetical example to demonstrate Monte Carlo simulation techniques, used debt interest rates and building rental rates as variables in his rate of return model. Jaafari *et al.* (1995) retrospectively applied risk scenarios, using Monte Carlo simulation, to a historical office building project to explore the impacts of cost variations, delays, occupancy rates and interest rates upon the internal rate of return. They concluded that a prudent pre-construction risk evaluation of the project in real life would have revealed its vulnerability to the property slump which subsequently endangered its financial feasibility. In a different financial context, Kangari (1991) noted that failure (ie. bankruptcy) of American construction companies was most frequently attributable to economic and financial factors (inflation, debt interest rates, inadequate capital). Some research has been carried out into the use of financial ratios as a method of predicting the likelihood of construction company failure (eg. Edum-Fotwe *et al.*, 1996). Overall, there is a surprising lack of authoritative case study reporting of economic and financial risk in the construction literature.

3.4.4. Legal risks

Risk allocation through the contractual aspect of building procurement came under scrutiny in the 1980's, marking the beginning of a shift away from a purely quantitative treatment of pre-construction contractor uncertainties to consideration of client risk (eg. Ashley, 1980a, 1980b; Handa and Georgiades, 1980; and Levitt *et al.*, 1980).

Although the processes and remedies of sub-contractor default are widely found in the construction contract law literature, analytical treatment of the risks relating to this issue have attracted little research attention. The same applies to ownership of materials on site, where the efficacy of contract vesting clauses has not been investigated from a risk management perspective. Here too, reports of case-based research are not to be found.

3.4.5. Health risks

The occurrence and impact of epidemics on construction projects has so far not been investigated as a risk management issue. A construction site, however, is an environment vulnerable to viruses and infectious diseases. There is little or no information about the incidence or management of these from an occupational health and safety, let alone a risk point of view.

3.4.6. Managerial risks

While construction and project management research now more frequently addresses issues in fields such as quality assurance, human resource management, and occupational health and safety, this is seldom done from a risk or risk management point of view, and these *managerial* risks are thus under-represented in the construction risk literature. An exception is the work of Lingard (1992, 1993) and Lingard and Rowlinson (1994) whose explorations of management strategies to improve worker safety behaviour have been an important contribution to occupational health and safety management knowledge for construction, with a clear focus upon risk reduction.

3.4.7. Technical risks

The application of probability theory is among the earliest quantitative approaches to construction and project risk. The main fields of application have been in contract bidding (tendering), cost estimating, and construction scheduling, all of which may be described as *technical* risks. They are not to be confused with economic or financial risks, as each originates in some expression of uncertainty, or error of judgement, relating to a technical operation (eg. the application of an estimating system, and the evaluation of its outcomes).

The early years (1960-1974) of the review period were dominated by attempts to model construction bidding processes. Much of this emanated in the USA, as evidenced by the work of Gates (1960, 1967, 1971) and Gates and Scarpa (1974). Generally, the research focussed upon the mathematics of uncertainty, relying on the analysis of variance and expected monetary values as the means for a shift from determinism, although Willenbrock (1973) and Carr (1977) took a utility function approach. Vergara and Boyer (1977) attempted to employ portfolio theory as a

means of encouraging contractors to spread their risks in selecting projects for tendering. Bowen (1984a) criticised portfolio theory, in an investment situation, claiming that it is an elegant, but artificial marriage of finance and mathematics. De Neufville *et al.* (1977) emphasised the need for bidding models to reflect factors such as economic climate, size of project and contractor risk attitude. More recently, Wanous *et al.* (2000) have proposed a parametric model for the bid decision, based upon the ranked importance of 38 factors. Chapman *et al.* (2000) have returned to the vexing problem of dealing with uncertainty in competitive bidding, basically advocating a disaggregation of project cost components which Pouliquen (1970) had earlier cautioned against.

Construction cost estimating became the second major focus for the use of probabilistic techniques. Spooner's (1974) work on probabilistic estimating was among the earliest in this field, and is seminal in terms of its comprehensiveness, dealing with various types of probability density function distributions, and incorporating the use of Monte Carlo simulation. Green (1978) followed a similar path, as did Diekmann (1983). Beeston (1983) comprehensively reviewed statistical treatments of building price data.

None of this early work was written specifically from a construction risk point of view, but this was implicit in the topics investigated: bidding and estimating.

Beeston (1986) proposed the inclusion of allowances for risk in construction estimating, with a combination of "fixed" and "variable" risk allowances; the former relating to risks with a known outcome and assessed probability; the latter referring to circumstances with varying outcomes and probabilities. His objective was to demonstrate a practical way of achieving a calculated probability of an estimate being exceeded, without recourse to complex statistical processes. He criticises an over-pessimistic approach where maximum values are allocated to the allowances, preferring instead to incorporate weighted average values, with a separate statement of the chance of a more pessimistic outcome. Although advocating the use of Monte Carlo simulation as an analytical technique, he points to the difficulties of using this where dependencies exist between risks. Byrne (1996), using spreadsheet-based @RiskTM software, demonstrates how this problem affects the risk analysis outcome values. The problem of dependencies (or correlations) between risk variables had earlier been raised by Pouliquen (1970), who suggested limiting the disaggregation of variables, or (preferably) isolating the individual uncertainties, as a solution.

Dressler (1974) introduced a stochastic concept for construction scheduling, pointing out the pitfalls of a deterministic approach to this task. His work was extended by Crandall (1976), and again later by Bennett and Ormerod (1984) whose work in the UK, particularly concerning the

use of Monte Carlo simulation, was substantially helped by the increasing availability of cheap and accessible computer power.

A trend detectable in all this work is the shift in focus – from the bidding phase to the estimating process and thence to the planning and scheduling of a project. This is an implicit acknowledgment of the need to track construction risks to their source.

Other technical risks generally not well-represented in the construction risk literature include those relating to site location and access, equipment and systems failure, new technology failure, and collisions and accidents. The risk associated with the introduction of new technology is an important area for research, particularly with regard to current emphases on information technology and the building procurement process. No one has examined the risk of failure or inadequacy of construction IT systems and the impact this might have on projects.

3.4.8. Cultural risks

Dingle (1991) describes cultural issues relating to risks in major international projects - a topic followed up by Swierczek (1994). Although the managerial difficulties of dealing with local cultural custom are perhaps more frequent and more pronounced for construction companies operating internationally, such issues are not confined solely to international construction activities. They are also to be found on home ground. For example, failure to understand and manage the proclivities of ethnic groups associated with construction (eg. Italian marble-workers; Irish labourers; unskilled Bangladeshi workers in Singapore; and migrant African labourers in South Africa) also exposes a contractor to cultural risk.

3.4.9. Temporal characteristics of risk

Finally, the temporal aspects of construction and project risk warrant consideration, particularly in terms of how the probabilities of occurrence and the impacts of different risks might each, or both, change over time for any given project. The impact of the risk of severe flooding, for example, diminishes as the structure of a building is completed, but for some civil engineering projects the risk may continue for the whole contract period. The probability of flood occurrence is likely to be seasonally influenced in many regions, and thus the timing of work on some projects becomes a factor to be considered. Similarly, the probability of a fatal accident occurring may decrease in the later stages of a building project, after scaffolding has been removed and site operatives concentrate upon internal work; but the probability may remain constant throughout a civil engineering pipe-line project. In either case, the impact of the adverse event might remain unchanged.

Hayes *et al.* (1986) sought to show how probabilistic cost distribution curves might change, from mesokurtic to leptokurtic, during the progress of a project, as uncertainty diminishes. Smith (1999) makes the same point in stating that project risk diminishes as more information becomes available. The opposite appears to be proposed by Byrne and Cadman (1984), but their three-dimensional temporal illustration of probability distributions is intended to illustrate not a dynamic view of a single risk variable, but a static representation of several variables viewed from the start of a project. The examples given above indicate that accepting that risk diminishes with time is only partly true for certain risks, and should not be treated as a general truism.

3.5. Risk management systems.

The text of Hayes *et al.* (1986) includes one of the earliest systematic treatments of construction risk, dealing with risk identification, risk analysis and risk response. Most texts prior to this had concentrated upon the mathematical approaches to risk analysis (eg. Hertz and Thomas, 1983, 1984; Byrne and Cadman, 1984).

The CRM Manual (1987) provides a procedural, task-based guide to construction risk management, as do Flanagan and Norman (1993) and Raftery (1994a). Later texts with a similar approach include Edwards (1995), Sawczuk (1996) and the Project Management Institute manual (PMI, 1996).

Cooper and Chapman (1987), although touching upon some aspects of risk management, concentrate largely upon risk analysis, using a case study approach to demonstrate techniques of moment analysis and influence diagramming. Raftery (1994a) adopts a similar approach, but uses less complex quantitative analyses for his examples. Chicken (1994) also concentrates upon risk analysis, in terms of the technical, economic and socio-political risks associated with government decision-making for large infrastructure projects. He demonstrates evaluation, which is mainly subjectively based, in order to produce risk rankings of alternative project solutions.

Despite their emphasis on risk analysis, Cooper and Chapman (1987) provide a useful summary of the rationale for formal risk management. They suggest that it is essential for informed decision-making on projects involving large capital outlays, unbalanced cash flows, new technology, unusual contractual arrangements, important political concerns, sensitive environmental issues, or stringent regulatory requirements.

By 1989, attempts had been made to use expert systems techniques in the analytical processes of risk management (Kangari and Boyer, 1989). Expert systems were also suggested for dealing with uncertain reasoning in construction legal issues (Diekmann and Kraiem, 1990). The use of “fuzzy sets” linguistics approaches has been proposed (Kangari and Riggs, 1989). More recently, Mak and Wong (1997) also advocate fuzzy sets as a technique for combining risks in estimating (*cf.* Beeston, 1986). Fuzzy logic is also proposed by Tah and Carr (2000) for project risk assessment, and by Wong *et al.* (2000) for project selection. Li (1995a, 1995b) has developed a neural network approach to uncertainty in construction cost estimation. Although more than a decade has now passed since the theoretical concepts of these techniques first began to appear in the construction literature, no case-based reporting of their effectiveness has occurred. This suggests that the construction industry perceives little advantage in adopting them.

Chapman (1994) cautions against the unfettered use of contingency allowances for risk, noting that unspecified contingencies simply tempt people to use them for other purposes. Little documentary evidence exists of research showing how pre-construction project risk contingencies are subsequently dealt with in terms of financial administration of contracts.

Guidelines have been published for the development of “risk severity matrices” in risk management (AS/NZS 3931, 1995; AS/NZS 4360, 1995) and the concept of a project life-cycle context for risk management has been proposed (Ward and Chapman, 1995).

The matrix approach attempts to rank risks in terms of their probability of occurrence (by numeric scoring on a scale from low to high) and impact (low to high) in order to identify those risks which might be ignored and those which must be dealt with. Risks are then ranked (either by adding or multiplying their probability and impact scores). Writing later on this topic, however, Ward (1999) suggests that such matrices (which he now refers to as “probability-impact grids”), while superficially helping to reduce subjectivity in risk assessment, lack absolute meaning and fail to accommodate the potential range of values for probability and impact that might be attributable to each risk. Ward suggests replacing the numeric with alphabetical values. In this way, for example, a risk might be rated as “AA” or “AC”, rather than being scored arithmetically. Using this approach, risk management can be implemented in terms of organisational policy decisions. Thus an organisation might elect to “ignore all risks in Categories ‘BC’ or less”, or at least assemble them into a homogenous group to be dealt with collectively; in this way limiting the amount of managerial effort required (Ward, 1999).

Raftery (1994b) suggests that the risk identification stage of risk management has not been adequately addressed in the literature to date, and his assertion is supported by the findings of this review. Williams (1994) advocates a “risk register” component in the management system of a project to generate an accessible database of risk experiences. Ward (1999) believes that the information in such an historical register should include such detail as:

- *risk identifier, title and description*
- *description of causes and trigger events*
- *description of impacts on cost time and quality, and quantitative assessment of range of impacts where appropriate*
- *nature of any inter-dependencies with other sources of risk*
- *timing of likely impacts*
- *probability of occurrence*
- *description of feasible responses, including timing required*
- *resource implications of responses*
- *likely effect of response on this risk*
- *nature of any significant inter-dependencies with other risks and responses*
- *residual risk after effective response*
- *party bearing the consequences of the risk*
- *party responsible for managing the risk and implementing responses*

(Ward, 1999)

While such registers might provide evidence of a careful and systematic approach to risk management, the *manner* in which managers go about identifying risks on new projects is also important, as are the issues relating to goal setting for construction and project risk management; risk response processes; and risk monitoring and review procedures.

3.6. “Soft systems” aspects of risk management.

Much of the literature on construction and project risk and risk management deals with the topic from a “hard systems” quantitative basis, suggesting the application of mathematical techniques in a formulaic manner, despite society’s recognition of risk as a *social construct* (Royal Society, 1991). Over the forty years of the literature review period, less than 20% of all publications have

considered risk from the perspective of the behavioural and attitudinal characteristics of the project stakeholders, and even over the past ten years this proportion has only risen to 25%.

While risk is: "...the probability that an adverse event occurs during a stated period of time." (Royal Society, 1991), this is really the label given by society to its perception of such events, and is thus a value-laden term subject to individual identification, measurement and response. Although it is possible to systematise these processes as *risk management*, the intrusion of personal values cannot be ignored. These may emerge as biases in judgement (Birnie, 1993).

A "soft systems" management view in construction management research is first detectable in the 1960's (although this preceded the actual labelling of such an approach). Higgin and Jessop (1965) reflected upon the inadequacies of interpersonal communication in the construction industry in the United Kingdom, and the Tavistock Institute (1966) published a report on the findings of an investigation into the inherent uncertainties surrounding construction projects and the UK construction industry. The objective of both these publications was to encourage improvements in the procurement practices of the British construction industry. The extent of their success is measurable by the publication of the Latham report (1994) nearly thirty years later, which made similar criticisms of industry practices, and similar recommendations for improvement. The fact that construction is as much a social, as a technical, process appears to be hard for the industry to accept and act upon.

Early recognition of the difficulties posed by a purely "hard systems" approach to risk management came from Hertz and Thomas (1984), in the preface to their text:

" ...the people problems of implementation of risk analysis in organisational contexts are by no means easily soluble and we strongly believe that the literature should direct more attention towards feasible approaches for handling implementation issues."

To date, research into human aspects of construction and project risk management has concentrated upon three discernible areas: the establishment of subjective probabilities; the exploration of heuristics and biases; and surveys of risk management practices in the construction industry.

A few researchers have addressed the major difficulties of using probabilistic techniques in risk analysis - the establishment of subjective probabilities, and the selection of appropriate types of

probability distributions. Wilson (1984) used a hypothetical dialogue between risk analyst and client to demonstrate the establishment of probabilities for variables to be included in a decision tree analysis of the feasibility of a retail store design project. Ranasinghe and Russell (1993) have proposed and tested a Delphi approach to the elicitation of subjective probabilities, but note the difficulty of calibrating results; while Raftery and Ng (1993) have suggested a knowledge-based system approach to risk analysis, using fuzzy language sets, qualitative reasoning and knowledge elicitation. None of this work appears to have resulted in more than limited application by construction professionals in practice (see the discussion of survey research in Chapter 5, section 5.2.1). This supports Byrne and Cadman's (1984) view that the measurement of probability is alien to most decision-makers, who are happy to take an intuitive approach but reject procedures which require more formal treatment.

Mak (1992, 1995), Mak and Raftery (1992) and McKim (1991, 1992) have investigated behavioural approaches to decision-making, applying the human bias findings of the earlier pure theorists in the specific context of construction and project risk management. Birnie (1993) has contributed to this field through his research into the judgemental biases of quantity surveyors in unit rate estimating for project cost planning. The general conclusion to be drawn from the work of these researchers is that professionals in the construction industry exhibit similar heuristics and biases in their judgements as the population at large, ie. their inherent decision-making *abilities* are not significantly better; suggesting that most construction professionals could benefit from a more explicit and thorough understanding of the intellectual processes of decision-making (Raftery, 1994b).

The later periods of the analytical review (1991-1995 and 1996-2000) reveal a flurry of publications dealing with the findings of opinion surveys about risk management practices in the construction industry. Topics covered in these surveys have included risk management experience; risk identification and ranking; risk analysis techniques; risk responses; and communication effectiveness. Generally, the findings of the survey-based research support the proposition that construction professionals lack an adequate understanding of the rationale and formal processes of project decision-making under risk and uncertainty. Chapman (1994) believes this is true even in organisations where such processes are in frequent use; thus implying that formulaic techniques (particularly computer-based applications) are being used in a mechanistic, "black box", manner.

Much of the survey-based opinion research, into construction and project risk management practice, presented in the construction risk literature reveals findings which are generally

inconclusive and shallow, and sometimes conflicting. This suggests a methodological weakness in that inappropriate research methods may have been used, and this criticism is discussed more fully in Chapter 5.

The treatment of risk and risk management in the construction literature perhaps also need to be viewed in the context of progress in this field in other sectors. While the overall increase in the publication rate of construction risk-based literature (Fig. 3.2) is laudable, it should be set against anecdotal evidence of a sharp rise in interest in risk and risk management in other industry sectors. The clearest indication of this is found on the Internet. A keyword search engine procedure (using "risk management") used at the start of this research in 1996 yielded approximately 3,500 known sites, none of which clearly related to construction. Repeating the procedure at the start of 2001 produced more than 2.4 million sites. Inspection of 500 of these revealed only 12 sites relating to project or construction risk management. Of the others, most were concerned with finance and insurance industry concerns, publicising either professional associations for risk management or the services of risk management consultants. Several sites (particularly in the USA) publicised the establishment of university research centres in risk and risk management, again with a finance or insurance focus. Many sites were found to relate to the governance of public sector organizations, particularly in terms of procedures to mitigate their public liability risks, where the organizations (eg. State of Texas, University of New South Wales) had set up specific departments to deal with these. The increase in Internet references over five years needs to be considered with caution. For example, permanent organizations are more likely than temporary organizations (such as construction project organizations) to publicise their activities through this medium. The point here, however, is that although awareness of the need for greater understanding, of risk and risk management, has been shown in this chapter to be increasing in the construction industry, it may well continue to lag that found in other sectors.

3.7. Conclusions.

The themed temporal review of the construction risk and risk management literature over the period 1960-2000 shows that the earliest and most frequent research contributions have taken the form of quantitative applications of risk analysis techniques. In later years these have begun to decline in favour of the exposition of risk management systems and studies of human involvement with them.

The main fields of quantitative risk analysis research have been in the managerial and technical categories of risk, eg. contract bidding (tendering), cost estimating, and construction scheduling. The political, economic, financial and cultural categories of risk are largely under-represented in the research literature, as also are risks associated with quality assurance and occupational health and safety.

Risk management systems have generally been thoroughly expounded in the literature - more so in texts than in journal papers. However, the identification of construction risks deserves more investigation. Categories of risks should be explored (on a case study basis) in terms of nature of occurrence, impact and response alternatives, and attention should be given to the temporal characteristics of risk.

The "people problems" of construction risk management are currently being subjected to substantial research effort directed mainly at the establishment of subjective probabilities; the exploration of heuristics and biases; and the nature and extent of risk management practices in the construction industry. However, there is a need to investigate differing risk attitudes among project participants (ie. risk profiling); how risk learning occurs; the learning effect of risk experiences on risk attitudes; and the ways in which inter-personal communication of risk takes place in the temporary multi-structure organisations of construction projects. This research should be undertaken in relation to specific construction risks, rather than from a more general viewpoint.

Finally, evidence of a substantial increase in other industry sectors (and in public organizations) of the need for greater awareness and understanding of risk and risk management should spur the construction industry (and project stakeholders) to adopt similar objectives.

These issues will influence the development of the research design for the current research, which focuses upon risk perceptions and risk management practice, including risk communication. Before that design can be attempted, however, it is necessary to consider how risk allocation and decision-making occurs, and how they are communicated, within the organisational structures of building procurement systems. This is done in Chapter 4.

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University of Cape Town

CHAPTER 4

DECISION-MAKING, RISK ALLOCATION AND COMMUNICATION IN ORGANISATIONAL STRUCTURES OF BUILDING PROCUREMENT SYSTEMS

4.1. Introduction.

This chapter addresses the subsidiary questions: *What are construction projects and their environments?* and *Who are the project participants and how does project decision-making occur?* The answers will provide the necessary context for the collection of the primary data for the research.

The essential background, against which construction and project risk management takes place, is described. All construction projects, regardless of size or scope, proceed within some form of organisational system aimed at achieving the project objectives. The *meta*-systems of building procurement will be identified and their organisational characteristics explored.

Each project involves a variety of stakeholders, and it is their organisational interactions which bring the project to fruition, completion and operation. Project decision-making, and *inter alia* risk allocation, occurs as part of these interactions and, as noted in Chapter 2, it is within the decision-making context of projects that risk management occurs. Because stakeholder interactions inevitably involve interpersonal communication processes, these are also discussed.

4.2. Project environments.

Construction projects arise within the broad environment of the construction industry, which is influenced by a myriad of factors relating to urban, regional and national development needs and the monetary and fiscal policies of government. Construction itself contributes significantly to national gross fixed investment, yet competes with manufacturing and other industries for capital investment and resources. The construction industry exerts economic influence through mega-projects and the aggregation of smaller projects, but on an *intra*-industry basis, projects also compete with one another for resources. The clients of the construction industry are institutional

and individual, public and private, and its products may form the essential services and transport infrastructure of a nation, or be used to satisfy the spatial accommodation needs of commercial, industrial, agricultural, educational, residential, health, social and religious, administrative, sporting, tourism or leisure activities.

Given this level of diversity, it is unlikely that a single type of organisational structure could suit all projects, and yet it is to this environment, according to Miles and Snow (1978), that the project organisation must be aligned. Project stakeholders must resolve three types of problem simultaneously: entrepreneurial (the right project); engineering (the right technology); and administrative (organising the work).

It is the various systems of building procurement which address this triple problem, and within these systems organisational structures are developed for each individual project. The systems themselves have arisen out of attempts to optimise, control or resolve issues relating to, one or more of the objectives of time (minimum time required to complete), cost (lowest cost consistent with required quality) and quality (fitness for purpose) applicable to all projects. However, in order to simplify the task of categorising them, the *meta*-systems of building procurement should comprise sufficiently large groupings distinguished by as few and important characteristics as possible.

4.3. Building procurement systems.

“Procurement” is defined by Franks (1990) as *“the amalgam of activities undertaken by a client to obtain a building”*. More accurately, perhaps, since the client is not wholly involved in every activity, it is the amalgam of activities undertaken in order to satisfy a client’s building needs. “Procurement system” therefore assumes that these activities are organised in some recognisable and systematic manner, and it is the organisational differences, and objectives, which distinguish different systems.

Masterman (1994) has categorised building procurement systems under four types. The first of these, which he describes as “separated and co-operative”, includes the conventional system of separation of design and construction allied to competitive lump tender, together with its variants such as selective tendering, negotiation, serial tendering, continuity contracts and cost-reimbursable contracts.

The second type of procurement system is referred to by Masterman as “integrated”, and here he includes design and build (where sole responsibility for these two functions is assigned to the contractor) and its variants such as package deal, turnkey and develop and construct.

The third type comprises “management” oriented procurement systems, including construction management, management contracting and design and manage, where the focus is upon the provision of management services (eg. co-ordination, control and administration) to the client by the contracting party. Under this system, the actual construction work is carried out by specialist sub-contractors, who may be contracted directly to the client (construction management variant) or to the management organisation (management contracting variant). Because design may be dealt with in the conventional manner (by consultants engaged by the client), or as part of the management service (design and manage variant), or as a sub-contractor role, this system fundamentally comprises hybrid versions of the first two systems, as does the “novation” system – yet a further alternative described by Chan (1996). Under novation, the client separately engages professional consultants to develop the project design to an agreed preliminary stage. Subsequently an integrated design and build procurement approach is adopted for completing the design and constructing the project.

The fourth type of procurement system identified by Masterman (1994) is the “British Property Federation” system. The focus of this system appears to be upon the activities of a person known as the “client’s representative”, who might be from any of the building professions, and whose organisational activities most closely resemble those of a project manager. From Franks’ (1990) detailed procedural description, it can be concluded that this is yet another variant of the “separated” building procurement system, since design activity is separated from construction activity.

It can be argued that the *meta*-systems of building procurement should be distinguished primarily by the location of the responsibility for design in relation to the responsibility for construction activity, since these are the crucial activities in the whole process. Systems where the contractor does not have major design responsibility are therefore “separated”; while those where the contractor does have this responsibility are “integrated”.

The completed project should be fit for its purpose in terms of the client’s requirements, and achieved at an acceptable cost, to a satisfactory standard of quality, within an appropriate time frame (PMI, 1996). It is the *proactive* level of assurance sought by the client about fitness for purpose which will largely influence the choice between a separated and integrated procurement

system for a project. Where a high level of assurance is sought, together with a high level of flexibility in terms of decision-making and commitment to proceeding with the project; then a separated form of procurement is advisable. Where there is little doubt about the eventual fitness for purpose of the completed project, and little flexibility for decision-making and commitment is required; then an integrated procurement system may be employed.

Within the two fundamental building procurement systems (separated design and integrated design), variants determine the locus and scope of the organisational activities of the project (eg. management and administration). The contractual linkages (express and implied) established in the organisational structures will then play a part in allocating responsibility for project and construction risks.

4.4. Organisational structures.

While its organisational structure must be regarded as unique to each individual construction project, and while this organisation will be staffed by unique people, distinguishable by their place and purpose in the organisation, nevertheless such people should share a common objective as stakeholders in the project. However, a consistent, unified view of objectives is not inevitable in practice (Bowen *et al.*, 1997), and the “team” label frequently applied to combinations of project stakeholders (eg. design team, project team, construction team) must be understood in the light of this.

Given that the *meta*-systems of building procurement are distinguished by the extent of contractual separation in the design and construction activity roles; and that variant systems identify the loci and scope of other organisational functions, it is now possible to define some of the many possible variations. Figures 4.1 to 4.5 show five alternatives. Solid lines indicate where contractual and communication links exist with the client; although these may not occur to a consistent level or extent. Dotted lines indicate contractual and communication links initiated only by, and with, the main contractor, and which may be “hidden” from other stakeholders.

Figure 4.1 is representative of the conventional *separated* building procurement system, common in Great Britain and in most countries influenced by British colonial administration since the early 1800’s. The project is architect-led, and the activities of the professional, consultancy-based design team are clearly separated from the construction activities. The diagram also reflects the curious and problematic contractual situation of nominated sub-contractors under this system.

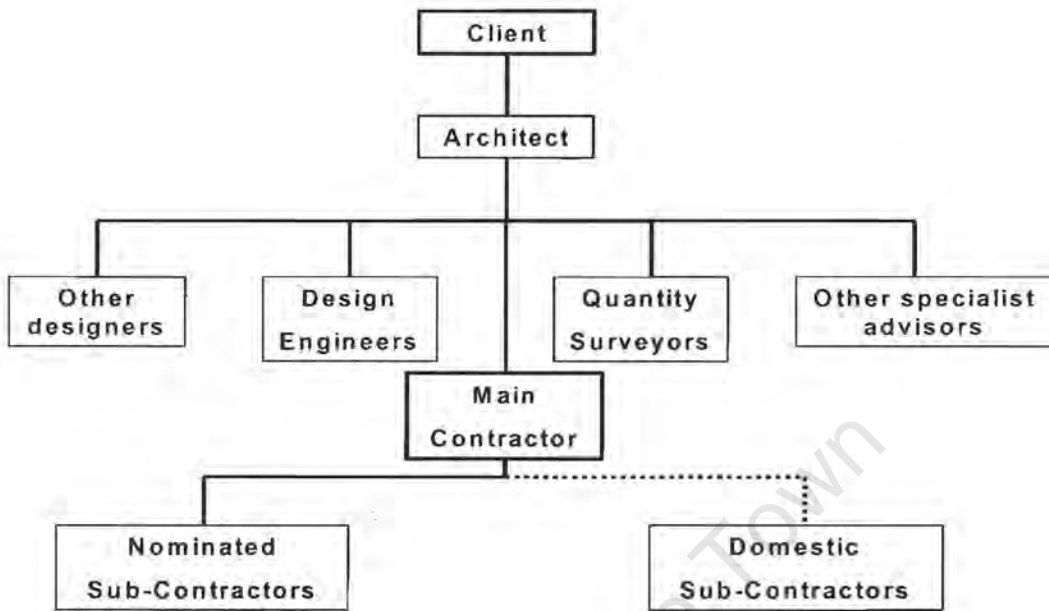


Fig. 4.1. Conventional 'separated' building procurement system.

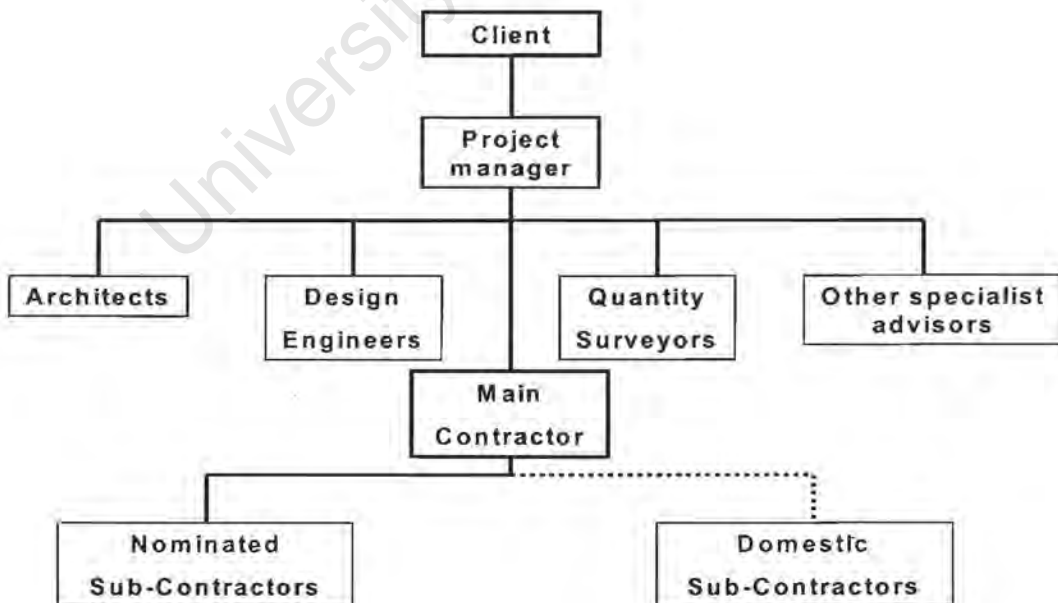


Fig. 4.2. 'Separated' building procurement system (project manager-led)

A similar “separated” procurement system is shown in Figure 4.2. Here, however, the system is led by a project manager, who may be an independent consultant or appointed “in-house” from the client organisation.

A simple form of “integrated” building procurement system is shown in Figure 4.3, representative of the “turn-key” or “package deal” variants of this system. Here there is no transparency of design activity, which is entirely the responsibility of the contractor, and the identity of the designers may be completely unknown to the client. This may also be true of the sub-contractors, although their identities are likely to become evident on site signage.

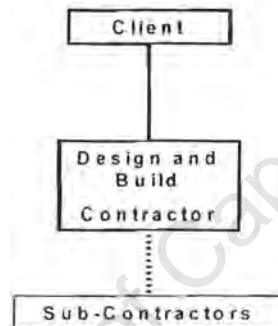


Fig. 4.3. ‘Integrated’ building procurement system.

Figure 4.4 illustrates an “integrated” procurement system where the project is led, on the client’s behalf, by a project manager. As with Fig. 4.2, this stakeholder may be professionally independent or appointed “in-house”. In this variant, the design team would comprise professional consultants appointed by, and responsible to, the main contractor. It is likely, but not inevitable, that their identities would be known to the client.

Figure 4.5 provides an example of the hybrid “novated” building procurement system. Here the contractual and organisational linkages of the pre-novation stage of the project are indicated by thin solid lines.

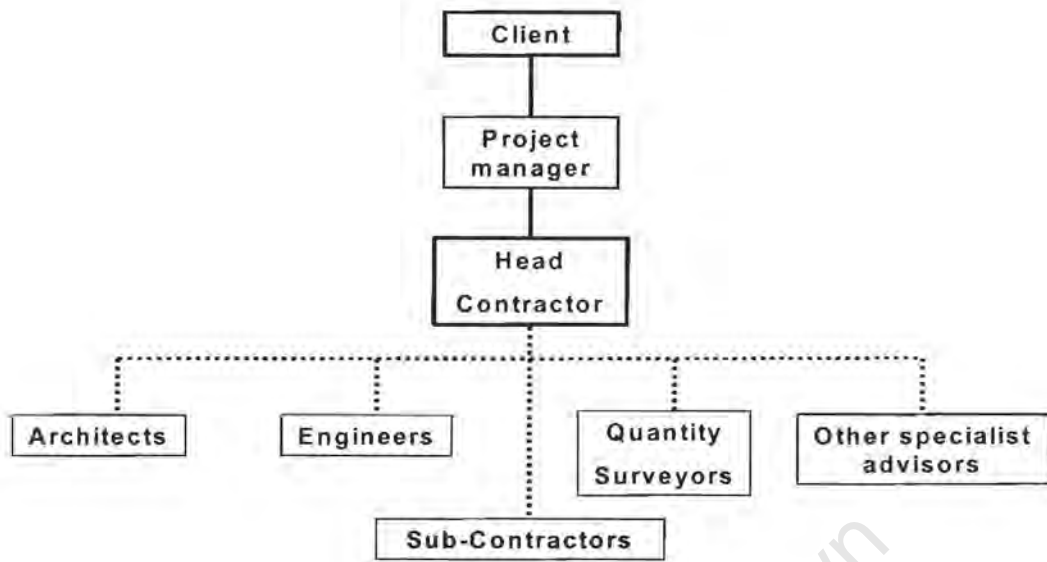


Fig. 4.4. Project manager-led 'integrated' building procurement system.

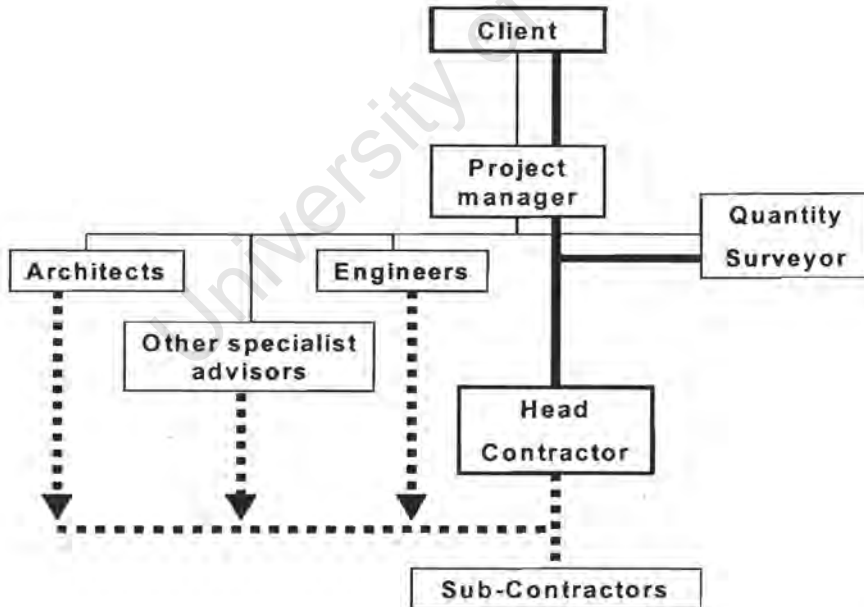


Fig.4.5. Hybrid 'novated' building procurement system.

The thicker solid and dotted lines show the relationships after novation has taken place. It is not unusual in this system for the project manager and quantity surveyor to continue to represent the client's interests; while the services of the design specialists are contractually transferred to the contractor at novation.

These diagrams are simplified representations of a few of the many organisational variations possible under the "separated" and "integrated" systems of building procurement. Overall, they can be seen as simple structures in Mintzberg's (1979) view of organisational structures, with a strong resemblance to temporary professional bureaucracies. However, to some extent they are also characteristic of operating adhocracies in that they have a project basis and are flexible, renewing and organic; using liaison devices (eg. project managers) to negotiate and co-ordinate activities.

As Mintzberg (1979) notes, however, beyond every "adhocracy" lie corresponding organisational bureaucracies, doing similar work, but with narrower focus or orientation. These are the *loci* of some of the project stakeholders who will be the target of this research and who must, therefore, be identified.

4.5. Project stakeholders.

A project stakeholder is any entity which has the power to influence project decision-making directly, or which is affected by the event or outcome of a project.

A Singapore Government report (MOM, 1999), dealing with the strategic development of the construction industry in the 21st century, identifies the key players (stakeholders) in construction projects as:

- Developers (clients)
- Architects
- Engineers
- Quantity surveyors
- Project managers
- Regulatory bodies
- Main contractors
- Sub-contractors
- Site supervisors
- Site workers
- Management corporations (facilities managers)
- Users

To complete the construction supply chain, other entities should be added to this list, such as town planners, land and building surveyors (generally acting on behalf of regulatory bodies) and materials and equipment manufacturers and suppliers (as an extension of contractors' activities). Similarly, in terms of project events or outcomes, "users" might be expanded to include specific interest groups and even the general public.

However, in the *proactive* risk management context of this research (see statement of limitations in Chapter 1), not all of these players are involved in the early stages of a project, nor do they play a direct role in the decision-making environment of project risk management. The investigation will therefore not extend to regulatory bodies, the extensions of contractor activities beyond sub-contractors, and post-occupancy management corporations and users.

The organisational structures of the stakeholders will also impact upon the way project decision-making occurs and the way it is communicated. Here the important features are the nature of the prime co-ordinating mechanism of each organisation, and the type and extent of centralised/decentralised decision-making within it. Stakeholder organisations, given that they each play different roles, are likely to display wider variation than project organisations. Mintzberg (1979) again provides models to represent them. Table 4.1 reflects this range of organisational structures.

<u>Structural configuration</u>	<u>Prime co-ordinating mechanism</u>	<u>Key part of organisation</u>	<u>Type of decentralisation</u>
Simple Structure	Direct supervision	Strategic apex	Vertical and horizontal centralisation
Machine Bureaucracy	Standardised work processes	Technostructure	Limited horizontal decentralisation
Professional Bureaucracy	Standardisation of skills	Operating core	vertical and horizontal decentralisation
Divisionalised form	Standardised outputs	Middle line	Limited vertical decentralisation
Adhocracy	Mutual adjustment	Support staff	Selective decentralisation

Table 4.1. Organisation structures and characteristics (Source: Mintzberg, 1979).

Exploration of discrete project stakeholders, in terms of this array, will be necessary if light is to be shed upon their decision-making and risk and risk management perceptions and practices.

4.6. Project phasing.

Smith (1999) notes that the procurement of building projects is frequently a disjunctive, rather than a continuous, process. Project phases, such as those outlined by the RIBA (1991) do not necessarily flow seamlessly from one phase to the next, but may be interrupted by exigencies such as, *inter alia*, the availability of funds, the state of relevant markets, the availability or development of suitable technology, and the fluidity of the design process itself in satisfying client objectives. Nevertheless, while such disjunctivity may impact upon risk management through the influence of time, these phases mark points at which major decision-making occurs, and are described by Walker (1996) as the "pinchpoints" of project procurement.

4.7. Organisations and decision-making.

4.7.1. Modes of organisational management.

Parkin (1996) views management decision-making as "*...the re-traceable expression of the process of organising.*", noting that much of project decision-making is guided by codes and specifications and that control of knowledge and information is the decision-making power source of professional groups or highly skilled technicians.

He subscribes to two contrasting modes of organisational management: the administration mode of ordering (structure, hierarchy, function, control, adaptability); and the enterprise mode of ordering (meaning, interests, power, politics, symbolism). The contrast is in terms of interests, conflict and power. For interests, the administrative mode of organisational management will try to achieve a set of common objectives and work closely together to achieve them; while the enterprise mode recognises individual *and* group interests and the organisation becomes a loose coalition or alliance of these interests (Newcombe, 1994; 1997). The administrative mode of organising seeks harmony and the removal of conflict; while the enterprise mode accepts conflict as a natural, and often desirable, feature of organisations. In terms of power, the administrative organisation prefers clear lines of authority, leadership and control; while the enterprise mode recognises the power of groups and individuals in resolving conflicts of interest in the organisation.

Given the above characteristics, construction projects can be seen to be predominantly ordered under the administrative organisational management mode.

4.7.2. Decision-making

Russo and Schoemaker (1989) describe four key elements to effective decision-making:

- Framing (understanding the issue/problem in its proper context (eg. the objectives and success criteria for the project).
- Gathering sufficient information about the issue/problem.
- Systematically drawing conclusions.
- Learning from feedback.

Parkin (1996) offers a slightly different view:

- Problem recognition (= framing)
- Information and analysis
- Judgement (concluding)
- Deciding/acting

Fortune and Lees (1996) theorise decision-making in the context of construction projects where a professional consultant (eg. quantity surveyor) is called upon to offer strategic cost advice to a client. Figure 4.6 illustrates this approach.

Essentially, the diagram shows that initially some form of *intra-stakeholder* technical decision-making process (referred to by Bowen (1993) as *intra-personal communication*) occurs; e.g. with respect to types of cost model and sources and treatment of input cost data. The cost model outputs are then subjected to a process of professional judgement by the consultant (eg. manipulation, translation and interpretation). This is allied to a process of professional judgement about how the consultant's advice should be communicated to the client. After the advice has been communicated, through whatever communication channels and transmission media which have been established in terms of the organisational structure of the project, the client will engage in his/her own decision-making processes. The Fortune and Lees (1996) model suggests two distinct aspects to the whole consultant/client decision-making process: formulation of the advice (incorporating series of technical mini-decisions on inputs and outputs by the consultant); and communication of the advice to the client. The "hinge", or fulcrum, of the process is seen as the point at which consideration (judgement) of the nature/quality of the advice itself turns to consideration of how it is to be communicated to the client: marking also the point of transition between cognitive and behavioural decision-making (Fortune and Lees, 1996). This corresponds

broadly with the modelling application and output communication view of cost planning postulated earlier by Bowen and Edwards (1994).

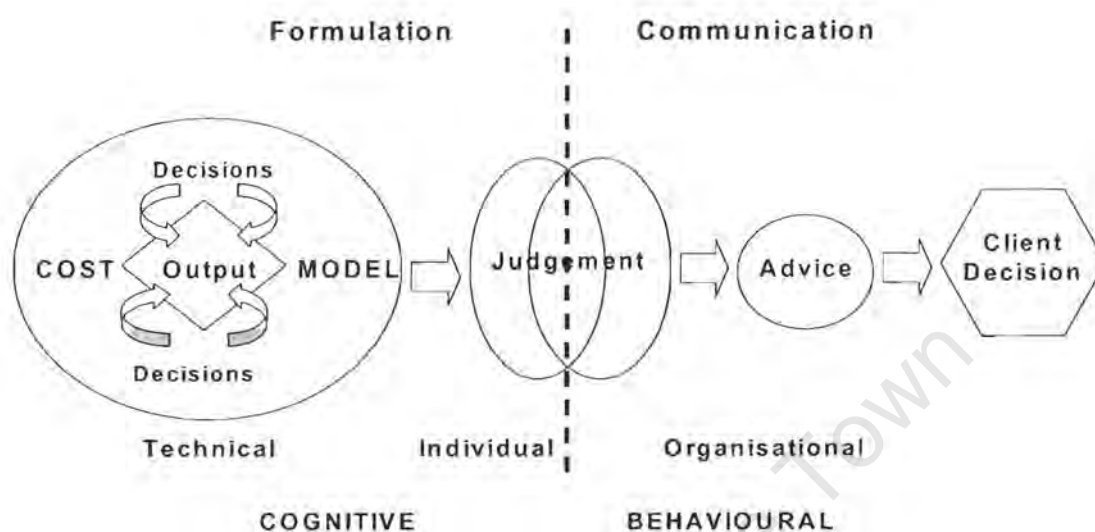


Fig. 4.6. Consultant approach to provision of strategic cost advice (adapted from Fortune and Lees, 1996).

Fig. 4.6 also suggests that processes for *group* decision-making in construction projects may differ considerably from the popular view of groups. Decisions are not necessarily made in a physical group environment, i.e. where all relevant stakeholders are gathered together for the purpose. Instead, technical decisions may occur first in an individual *intra*-stakeholder environment, and their outputs are then communicated through the project organisational structure for flow-on or strategic follow-up decisions by other stakeholders (i.e. group members).

Whichever theoretical view is preferred, it is clear that effective decision-making should flow from an explicit and systematic process. When decisions fail, or are less effective than anticipated, the causes are likely to be found in the process and/or the participants.

According to Russo and Schoemaker (1989), ten barriers to good decision-making are:

- 1) Hasty conclusions (not allowing sufficient time to elaborate all the issues)
- 2) Frame blindness (not setting the decision issues in their correct context; eg. project objectives ignored).
- 3) Lack of frame control (allowing the problem context to "drift").
- 4) Over-confidence in your own judgement (being too sure of your own assumptions and opinions while failing to take contra-indications into account).
- 5) Over-reliance on heuristics (using "rules of thumb" inappropriately)
- 6) Over-reliance on intuition (not following a systematic approach)
- 7) Group failure (allowing "group think" to occur)
- 8) Mis-reading historical evidence (ignoring reliable feedback)
- 9) Lack of on-going monitoring and control (failing to track the progressive outcomes of decisions)
- 10) Inadequate recording (failure to record the decision-making process properly leaves you vulnerable to repeating poor decisions).

Of these, the first barrier (hasty conclusions) might be encountered on projects where time for completion is a high priority. Barriers (2) and (3), frame blindness and lack of frame control, could arise where the group has no clear and common understanding of the project objectives. Raftery (1994b) and Birnie (1996) have each shown the dangers of barriers (4), (5) and (6) in decision-making for construction projects. The group failure barrier (7) is discussed later in this Chapter; while, in the context of risk management, mis-reading historical evidence (8), lack of on-going monitoring and control (9) and inadequate recording (10) are issues to be explored in this research.

The discussion shows that there are decisions to be made about the decision process itself (should the decision be made personally or by groups; where does the primary difficulty in the process lie?). This *meta-decision* process should precede decision-making.

It may also be important to consider the *order* effect of information upon decision-making. Research into cognitive psychology (eg. Hogarth and Einhorn, 1972; Crano, 1977) has suggested that, in situations where successive but opposed pieces of information are presented, a *primacy* effect on decision-making occurs where opinion is weighted towards the earlier information; while a *recency* effect is said to occur when judgement is more heavily influenced by later information. In formal risk management, risk identification and risk analysis must precede risk

decision-making. It is possible, therefore, that the order in which any conflicting information about project and construction risks is considered will influence stakeholder management of those risks. Stakeholders who exhibit primacy effects in their decision-making will be influenced more by early risk information. Stakeholders who exhibit recency effects in their decision-making will be influenced more by later risk information. However, the longitudinal research approach necessary to investigate this phenomenon on construction projects is beyond the scope of this research.

4.7.3. Group decision-making.

Of the barriers to effective decision-making noted above, one refers specifically to group failure. This is obviously important in the organisational context of construction projects.

Parkin (1996) notes that project teams are likely to be highly differentiated because of the wide range of skills which are required and brought together. However, they may not display a high level of organisational integration - at least in the early stages of a construction project - since the participants may not be familiar with each other and are likely to represent the particular interests of other separate organisations. Project teams are often required to deal with high levels of information; processing it and integrating it according to the needs of the project. In order to carry out this task, such groups must communicate effectively.

What is often not clear is the amount of individual decision-making that participants (project stakeholders) engage in *before* team decision-making occurs, but the earlier discussion of this Chapter (with respect to Fig. 4.6) suggests that this may be considerable.

Given the implicit heterogeneity of most construction project teams, the danger of group failure through the influence of "groupthink" (Janis, 1972) on its decision processes should be less than that faced by less differentiated groups whose members share a common organisational background. Nevertheless, the danger still exists, particularly if the decision problem has not been adequately framed and the group has moved too rapidly to convergence under an over-dominant leader in a high stress environment (Russo and Schoemaker, 1989). It cannot be said that these circumstances are never found on construction projects.

To summarise the exposition of this Chapter so far, risk arises in the decision-making context of construction projects, which themselves are part of a construction industry environment that supplies an extensive and largely unique range of products to meet the demands of urban,

regional, national and even international development. Project decision-making (individual and group-based) occurs within the organisational structures through which project procurement is achieved. These structures, and the contractual links they involve, largely determine how project risks are allocated and communicated. Risk decision-making, at the stakeholder level, includes the application of personal judgement and may be influenced by the order in which risk information is presented. We should not be surprised (and should even expect), therefore, to find that stakeholders do not share the same perceptions about risks and risk management. Poor decision-making arising from the influence of “groupthink” should not be a serious problem in construction projects, given the level of stakeholder heterogeneity and group differentiation in such projects, but this is not to say that poor decisions will not be made at all.

It is now possible to address the way in which the administrative mode of project ordering uses the organisational structures of various systems of project procurement in order to allocate risks to project stakeholders.

4.8. Allocation of risk.

Building procurement systems, their organisational structures and the ensuing contractual links should determine the allocation of project and construction risks.

Tables 4.1 and 4.2 show how, for a typical but not exhaustive selection of project and construction risks, slight differences between two variants of a *meta*-system of building procurement can substantially shift the allocation of risk. In Table 4.2, for example, under a conventional “separated” procurement system using a lump sum fixed price contract, the economic risk of greater than forecast increases in the costs of labour and materials is borne by the contractor, who may be able to transfer contractually some of this risk back to sub-contractors and suppliers. Compare this to Table 4.3, where, also under a conventional “separated” procurement system, but now with a lump sum, cost fluctuation reimbursable contract, much of this risk shifts to the client, since typically only the risk of a small non-reimbursable fraction of the cost increase (e.g. 15% in the case of relevant South African conditions of contract) is retained by the contractor and sub-contractors. In the latter case, suppliers may pass on the whole of their increased costs to purchasers, and contractor have little forecasting incentive since all cost increases may be claimed.

Identified Risk	Client	Project Manager	Design Consultants			Contractor		Supplier
			Architect	Engineer	Q.S	Main	Sub	
Unforeseen flooding occurs						Xti		
Unexpected geotechnical conditions found	X							
Theft occurs on site						Xti	Xti	
War breaks out	X							
"Green" project protest group halts project	X							
Increases in labour costs and material prices						X/Xct?	X/Xct?	
Unforeseen import tariffs imposed						Xct	X	X
Unforeseen interest rate increases occur	Xp					Xp	Xp	Xp
Unforeseen drop in project rental market rates	X							
Unforeseen imposition of harsher building codes	X							
Unforeseen structural design failure occurs				Xti				
Roof waterproofing design failure occurs			Xti					
Pre-contract cost planning error occurs					Xti			
Design co-ordination failure occurs		Xti						
Key staff lost	Xp	Xp	Xp	Xp	Xp	Xp	Xp	Xp

KEY: X = wholly allocated Xti = allocated but (partly) transferred by insurance Xct = allocated but contractually transferred Xp = parties bear their own share

Table 4.2. Risk allocation under typical conventional 'separated' building procurement system with lump sum fixed price contract.

Identified Risk	Client	Project Manager	Design Consultants			Contractor		Supplier
			Architect	Engineer	Q.S	Main	Sub	
Unforeseen flooding occurs						Xti		
Unexpected geotechnical conditions found	X							
Theft occurs on site						Xti	Xti	
War breaks out	X							
"Green" project protest group halts project	X							
Increased labour costs and material prices	Xp					Xp	Xp	
Unforeseen import tariffs imposed	X							
Unforeseen interest rate increases occur	X							
Unforeseen drop in project rental market rates	X							
Unforeseen imposition of harsher building codes	X							
Unforeseen structural design failure occurs				Xti				
Roof waterproofing design failure occurs			Xti					
Pre-contract cost planning error occurs					Xti			
Design co-ordination failure occurs		Xti						
Key staff lost	Xp	Xp	Xp	Xp	Xp	Xp	Xp	Xp

KEY: X = wholly allocated Xti = allocated but (partly) transferred by insurance Xct = allocated but contractually transferred Xp = parties bear their own share

Table 4.3. Risk allocation under typical conventional 'separated' building procurement system with lump sum contract with fluctuations provision.

Table 4.4 shows typical risk allocation under an “integrated” *meta*-system of building procurement encompassing a design and build contract between client and contractor. Much of the risk borne by the client in the “separated” building procurement systems (Tables 4.2 and 4.3) is now the responsibility of the contractor, who will clearly (competitive tender market conditions permitting) seek to reward himself for retaining these risks. In this example, the architect and engineer are assumed to be professional consultants engaged by the contractor, and the risk of design failure on their part may still be transferred by professional indemnity insurance. Where these professionals are employees of the contractor, the whole risk remains with the contractor.

Identified Risk	Client	Project		Contractor			
		Manager	Main	Sub	Architect	Engineer	Supplier
Unforeseen flooding occurs			X _{ti}				
Unexpected geotechnical conditions found			X				
Theft occurs on site			X _{ti}	X _{ti}			
War breaks out			X _{ti}				
“Green” project protest group halts project			X				
Increased labour costs and material prices			X _{ct}	X _p			
Unforeseen import tariffs imposed			X _{ct}	X _p			
Unforeseen interest rate increases occur	X						
Unforeseen drop in project rental market rates	X						
Unforeseen imposition of harsher building codes			X				
Unforeseen structural design failure occurs			X _{ct}			X _{ti}	
Roof waterproofing design failure occurs			X _{ct}		X _{ti}		
Pre-contract cost planning error occurs			X				
Design co-ordination failure occurs			X				
Key staff lost	X _p	X _p	X _p	X _p	X _p	X _p	X _p

KEY: X = wholly allocated X_{ti} = allocated but (partly) transferred by insurance X_{ct} = allocated but contractually transferred X_p = parties bear their own share

Table 4.4. Risk allocation under typical ‘integrated’ design and build building procurement system with fixed price contract.

A more conceptual view of risk allocation is presented by Walker *et al.* (2000). Through Figure 4.7 they demonstrate a gradation of procurement systems in terms of the “cost risk” to the client and contractor.

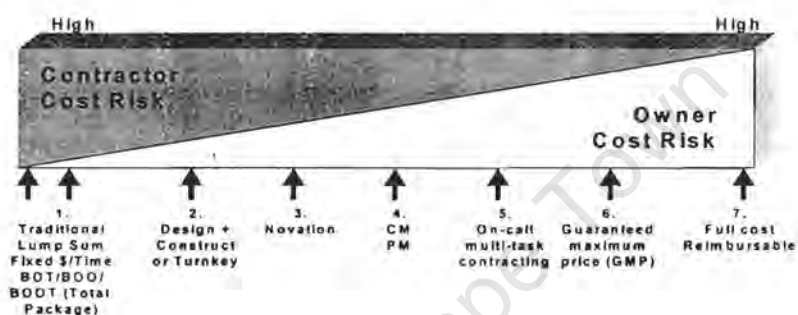


Fig. 4.7. A construction cost continuum for project delivery

(Source: Walker *et al.*, 2000)

Caution is necessary when considering the relative differences between alternative procurement systems in their capacity to allocate risks.

Neither the conceptual view of Fig.4.7, nor the allocations of Tables 4.2. to 4.4, are conclusive models of how specific risks are borne by stakeholders. They are simply indicators of some general differences in risk allocation which might be perceived. More conclusive evidence of specific risk allocation can only be found in the actual contractual conditions, relationships and processes arising out of the organisational structures developed from the procurement systems chosen for particular projects. Thus, for example, while it might be generally assumed that the risk of encountering adverse geotechnical conditions on site is allocated to the contractor under a typical “integrated” design and build procurement system (Table 4.4), nothing prevents the parties from allocating this risk to the client through the inclusion of an express condition in their contract agreement.

Procurement systems *per se*, therefore, may provide only a generalised indication of risk allocation, and information concerning the communication of such allocation must be sought in the contractual and other *minutiae* of each project. Some of this may be explicit, so that the identification and treatment of specific risks might be found in the contract clauses and conditions of agreement for the main building contract, the sub-contracts, the service agreements of consultants, or the delivery terms and warranty limitations of suppliers. An example of this is the risk of insolvency on the part of the contractor. Most standard forms of building contract include specific clauses to deal with this.

In other cases, a risk might be implied through a more general treatment stipulation. For example, the technical risk of error on the part of a professional consultant is unlikely to be mentioned specifically in a client/consultant service agreement, but may be implied from a clause requiring the consultant to provide evidence of stated levels of professional indemnity insurance.

Other risks may be dealt with neither explicitly nor impliedly in the contract agreement, but their allocation arises out of the particular role of one of the stakeholders. For example, a building contract may include no specific or implied reference to occupational health and safety risks, but these are allocated to the contractor purely on the basis of the statutory requirements pertaining to his construction activities.

How risks are communicated therefore becomes an issue of risk management.

4.9. Risk communication.

Bowen (1993), in the context of cost planning for construction projects, notes how communication has the objective of achieving shared meaning between senders and receivers. But what media are used for this communication, in terms of construction and project risk and risk management? While some risk allocation may be communicated through the medium of express contract clauses and conditions, it is unlikely that this suffices for all risks encountered on construction projects.

Early in this chapter it was noted that the organisational structures of various procurement systems reflect the communication and contractual links between the stakeholders. Murray *et al.*

(2000), however, through their longitudinal research, note that these structures may also represent the decision-making hierarchy of projects. Their research tests two important propositions. The first is that project organisational structures (in terms of the procurement systems used) are more “coactivational” than “configurational”. By “configurational” is meant the representation of the organisation as an archetypical image (such as those shown in Figs. 4.1 to 4.5), with a predominantly vertical portrayal of management authority relationships. This view assumes that the procurement system dictates the organisational structure; that the structure determines the formal communication path between participants; and that the formal communications along those paths reflect project decision-making to control the satisfactory completion of the project. It also assumes that the structure is pre-determined and designed, and that it is fixed over the project life.

The “coactivational” view, on the other hand, although it may initially adopt a configurational starting point, accepts that the organisational structure, whilst perhaps notionally remaining fixed, actually changes as it responds to the project dynamics and influences which participants bring with them and bring to bear on the project over time. Here informal communication is recognised as the essential “lubricating oil” for actually getting things done.

By exploring project incidents, and their communication patterns, Murray *et al.* (2000), whose research is not yet complete, hope to find greater support for the coactivational theory. Their work to date has shown two important findings: that unintended incidents in the lives of projects tended to create periods of uncertainty in the decision-making outcomes; and that project participants preferred informal communication methods for dealing with those situations. Mintzberg (1979) supported the use of informal communication networks as an aid to managing organisations.

These findings have obvious implications for the research being presented here, since risk arises in the decision-making context of projects (Chapter 2). If stakeholder risk perceptions and risk management practices are to be fully explored, it will be necessary to gather their risk stories through the medium of real-life project case studies.

The acquisition of a newly-built facility is not necessarily the sole determinant of procurement system choice; nor is all decision-making concentrated entirely on the specific needs of the project itself.

Edwards and Bowen (1996) explored communication as an imperative for the development of building procurement in South Africa, proposing that shifts in economic, social and

environmental circumstances could influence the choice of procurement systems, and hence the nature of the communication within them.

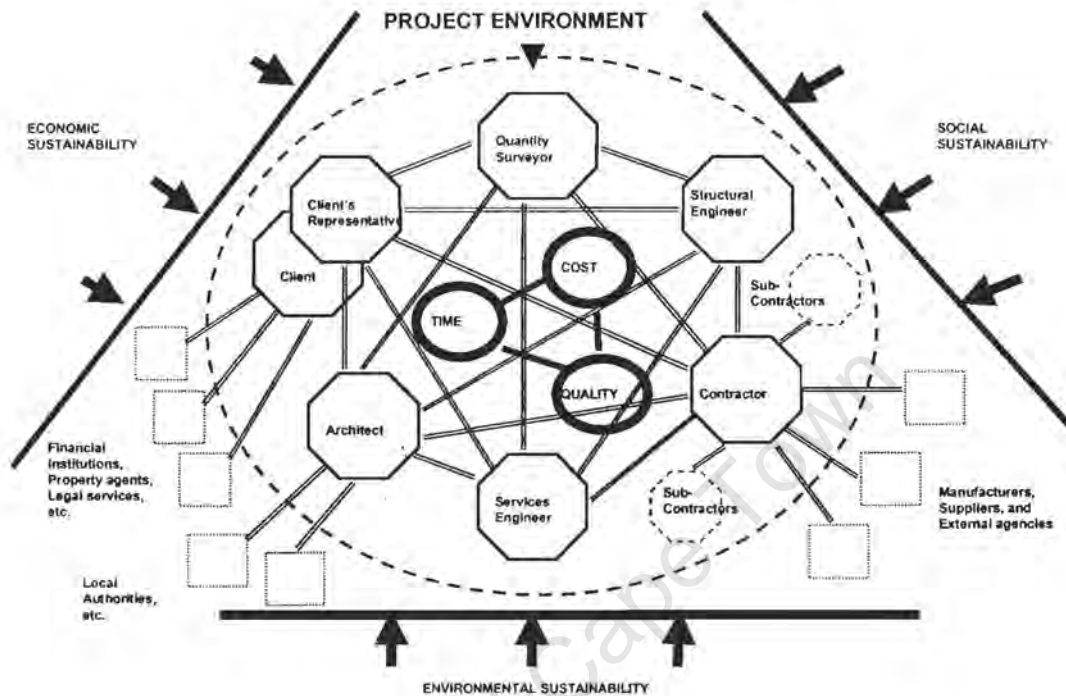


Fig. 4.8. Communication complexity and project sustainability pressures in a conventional 'separated' building procurement system

(Source: Edwards and Bowen, 1996).

Figure 4.8 illustrates the stakeholder communication complexity encountered in a conventional (traditional) separated procurement system, and the presence of economic, social and environmental pressures; while Figure 4.9 suggests that a “maze” of issues might have to be navigated in order to decide upon the most appropriate procurement system for a project. Not least among these is the allocation of risk. In a developing country, for example, a project client might wish to secure socio-economic benefits through the actual construction process by requiring the contractor (and sub-contractors) to engage unskilled workers as a minimum proportion of the project labour force and to train them “on the job”. Now the contractor is faced with a risk of more uncertain, and probably lower, labour productivity and the choice between absorbing this risk (and trying to reduce it through more effective management) or rewarding himself for the risk by increasing the tender price (and thus becoming less competitive). However, the client might

also wish to contribute to this socio-economic objective by offering a progressive tender bid advantage to tenderers willing to provide training to greater numbers of unskilled workers.

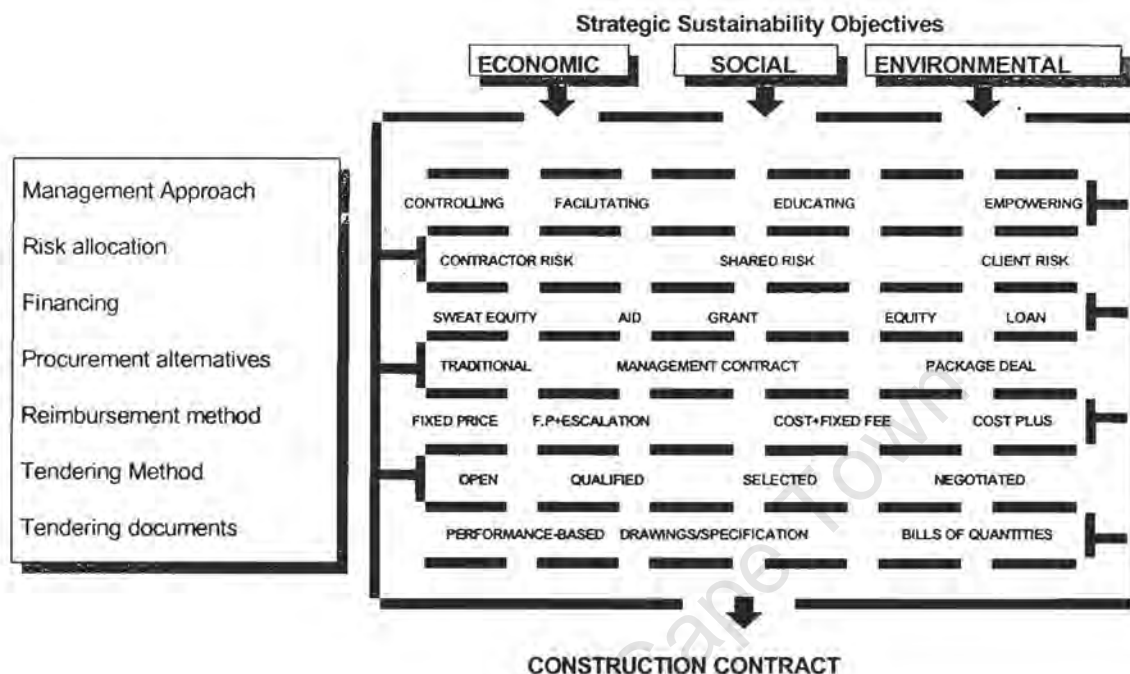


Fig. 4.9. Selected procurement issues and the decision “maze” for building project procurement (Source: Edwards and Bowen, 1996)

In such developmental socio-economic situations, a further objective might be sought in the entrepreneurial enhancement of previously disadvantaged sectors of the business community. Small, informal building organisations might be given a competitive tender advantage in order to encourage them to move towards parity with more established and more formal commercial entities. Now, to all the existing complexities of project objectives and environments, project decision-making, procurement systems and organisational structures, is added a further imperative for effective communication, particularly in terms of the risks associated with the project.

The study of risk and risk management for construction projects therefore should also consider the manner in which risk information is communicated.

Other issues of project, and project procurement complexity, are beginning to attract research attention. Williams (1999) even argues that, at a strategic level, a new paradigm of project

complexity is needed. He suggests that projects are complex in more ways than simply in terms of technical requirements and scope, and concludes:

"...overall project complexity can be characterised by two dimensions, each of which has two sub-dimensions:

- *Structural Uncertainty*
 - *Number of elements*
 - *Interdependence of elements*
- *Uncertainty*
 - *Uncertainty in goals*
 - *Uncertainty in methods.*"

(Williams, 1999)

This approach attempts to distinguish between complexities of the product (the completed project) and complexities in the processes of procuring it. It also aligns uncertainty with complexity, in terms of the instability surrounding the prior assumptions used in planning project tasks. This gives rise to several views on what might constitute a complex project. For example, a civil engineering road project might be structurally straightforward but complex in procurement because of its financing and ownership arrangements (eg. a BOOT project). A hospital project, on the other hand, might be straightforward in its procurement procedures but structurally complex through the co-ordination needs of its physical systems; while another project might be complex (or straightforward) in both aspects.

Given the association of uncertainty with risk, then project complexity is likely to be an important consideration for stakeholders in implementing effective project risk management.

4.10. Conclusions.

In this chapter the essential background to risk and risk management for construction projects has been explored.

The environment of construction projects is that of the construction industry itself as a sector of the national economy – an industry required to satisfy a diversity of demands. Within this environment, systems of procurement are devised, using complex administrative-ordered

adhocratic organisational structures, to deliver projects capable of fulfilling all the objectives sought for them.

Through these organisational structures, project stakeholders (each with their own organisational structure) engage in various levels of decision-making, using formal and informal communication in their dealings with one another. The risks surrounding project decision-making need to be effectively communicated, within stakeholder organisations and to other stakeholders. Anything that impacts upon stakeholders' understanding of risks, including the gathering of information about them, has the capacity to affect the management of those risks.

Given this background knowledge to construction projects, their organisational structures and their risks, derived through Chapters 2, 3 and 4, it is now possible to approach the process of collecting and analysing primary data for the research. Chapters 5, 6, 7 and 8 report on these tasks.

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University of Cape Town

CHAPTER 5

AN OPINION SURVEY BASED RISK MANAGEMENT

RESEARCH DESIGN

5.1. Introduction.

This chapter comprises the development of a survey based research design which will address one of the research questions posed in Chapter 1:

Do individual members of project teams have different perceptions of construction risk?

As a preliminary to establishing and designing the research instruments for this study of risk management, the extant survey-based construction and project risk management research literature, for the period 1991-2000, is first reviewed. This is done in order to highlight some of the weaknesses found in this single-technique approach to the research, and to further clarify the issues to be investigated.

The critical review leads to a summary of the major issues to be explored, and this is followed by a proposal and justification for a combined survey and case-based research approach. The survey design and case study protocols are then established.

5.2. Critical review of extant survey-based approaches.

5.2.1. The surveys

The following critique is based upon a chronological review of survey-based risk research published in authoritative journals and conference proceedings during the period 1991-2000.

A questionnaire survey of 47 contractors and interviews with 22 estimators/directors of construction firms, was used by Teo *et al.* (1991) to explore bidding processes for building refurbishment projects. The researchers found that contractors for this type of work were mainly concerned (from a tender pricing point of view) with the difficulties of estimating accurately; the credit-worthiness of the client; contractual liabilities; the type of job; and relationships with client

and consultants. From a construction activity point of view, respondents rated accessibility to the work, and productivity, as significant risks in refurbishment projects. The risk response strategy most frequently adopted by survey participants was that of risk reduction, generally through attempting to reduce uncertainty by obtaining additional information. The published findings do not discuss what estimators might do in situations where additional information cannot be obtained. Most of the findings of this research, other than the risk response finding, perhaps, might well have been deduced from the existing literature on estimating and pricing, building procurement, and construction management.

Bowen (1993) used a questionnaire survey to examine the techniques used by professional quantity surveyors in South Africa in the treatment of uncertainty during the project cost planning process. He found that respondents considered cost data uncertainty to be unacceptably high until the design concept stage (ie. the point at which graphic information, in the form of sketch designs, becomes available). In-house historical cost data were considered to be less susceptible to distortion - and hence less prone to uncertainty - than other published data. The use of range estimating appeared to be the most frequently-used technique for dealing with uncertainty. Bowen's research also dealt with the communication of risk issues within the project team; finding discrepancies between clients and consultants in terms of their perceptions of the manner and effectiveness of such communication. The value of this research lies more in its focus on communication than its findings about uncertainty.

Liu and Cheung (1994) surveyed the risk perceptions of 60 Hong Kong and Australian clients, contractors and consultants. Despite minor differences, due largely to different forms of contract, the research shows broadly similar findings for the two countries. The researchers noted with some concern that consultants' perceptions tended to be different to those of clients and contractors, and speculated that this might produce an undesirable bias into project decision-making. One technical weakness of this research is that the participant groups were unbalanced. The 40 respondents in Hong Kong comprised 17 employers (project clients), 17 contractors; and 6 consultants. The Australian sample (20) comprised 70% contractors (14), but no details of the remaining respondents are given. This means that most of the analysis could only be carried out in terms of the two main category groups (Hong Kong and Australia), and possibly the contractor sub-groups, as no validity could be claimed for findings dealing with comparisons between other sub-groups (eg. Hong Kong employers compared with Australian employers). It also weakens the findings of the main category group comparisons, as these are now heterogenous and not homogenous groups - other than all being involved with construction projects, of course. For example, at least one question asked survey participants to indicate their preferences about the

allocation of each of several risks catalogued (ie. to choose between allocation to employer; to contractor; or equally between the two - the option of a variable risk sharing allocation does not appear to have been made available to respondents). Because of the sub-group size imbalance, it is not possible to compare, say, the subjective opinions of Hong Kong consultants with Australian consultants about these allocations; and comparing the responses of the two main groups achieves little because the almost certain presence of sub-group bias cannot be controlled. Hence the weakening of the survey findings.

The same Hong Kong data appears to be used by Liu (2000) to explore factors affecting Hong Kong contractors' bidding decisions. Her findings with respect to risk allocation indicate that, for the standard Hong Kong form of contract (representing a conventional "separated" procurement system, nine types of risk were perceived by the survey respondents as the major risks to be allocated in the contract. Of these, respondent preferences suggested that the five performance-related risks (time for completion; managerial competence; nominated sub-contractor failure; labour, material and equipment supply; and defective work) should be allocated to the contractor. A shared allocation was preferred for the financial risks (price fluctuation and funding), for the physical risk of adverse weather, and for the legal risk of unfavourable imposition of building regulations.

Couillard (1995) explored the relationship between project management approach and project success, and then looked at the influence of risk on the project management approach. He found that project success correlated highly with project management approach in terms of team communication patterns and project goal understanding. Risk was found to correlate with experience in terms of project management - the riskier the project was likely to be, the more experience would be sought in the person appointed to lead it. While this finding supports a common-sense view, it puts no measure on the experience variable.

Simister (1995) found that checklists were the most frequently adopted method for risk identification, and that Monte Carlo simulation was the technique most often used for risk analysis. His survey respondents identified twenty-two computer-based risk analysis and management applications, of which the *@Risk*TM program was the most popular. Respondents (drawn mainly from the UK defence industry and management consultancies) suggested that the main benefit derived from the use of risk management processes was that it allowed the formulation of more realistic plans in terms of costs and timescales. As will be seen below, most of Simister's findings have not been replicated in surveys on similar topics carried out within the

construction industry, which suggests that consultants and contractors in this industry have some way to go to catch up with the risk management practices of other industries.

Tah *et al.* (1995), in a survey of the estimating practices of seven contractors, found that all of them classified risk as either “quantifiable” or “unquantifiable” (it is not clear how the survey instrument posed this question). For quantifiable risks, estimators included the costings in the estimate; while for unquantifiable risks an amount, based upon management perception of the situation, is added to the estimate either by increasing the profit mark-up or by including a lump sum in the preliminaries cost estimates. None of the respondents reported using statistical techniques to analyse risk.

Lewis (1995) interviewed six project managers and found that the occurrence of poor time management (a managerial risk) was commonly found in projects with outcomes considered less than successful. Respondents’ experience in quantitative techniques of risk analysis was severely limited: only one had used Monte Carlo simulation and had rejected it on cost and flexibility grounds. Nor was evidence found of the use of analytical techniques such as EMV (Expected Monetary Value) or RAR (Risk-adjusted Discount Rate). Most respondents preferred to incorporate contingency sums as a way of dealing with risk.

Pasquire (1996) used interviews to explore the risk perceptions of a project management consultant, a developer, and nine senior managers from large contracting organisations in the United Kingdom. Her interviewees generally regarded risk as belonging in either of two categories: insurable or uninsurable. For the most part, uninsurable risks were dealt with, either by some form of risk sharing (not explained), or by simply including contingency allowances, based upon experience or an intuitive percentage on-cost, in the cost estimates. Four companies were in the process of developing a more systematic approach to risk management for tendering purposes, but only one had actually implemented such a system with quantitative analytical procedures.

Potts and Weston (1996), in investigating changes in the procurement methods for major civil engineering projects, examined the risk management practices of 23 consultants, 14 contracting organisations and 2 “multi-disciplinary” companies, using a postal questionnaire survey. They found that nearly 40% of respondents had received some level of formal education and training in risk management. About half of the respondents adopted *qualitative* risk identification procedures for their projects, using checklists, interviews with key personnel, and brainstorming for the purpose. Fewer consultants (33%) than contractors (55%) used *quantitative* risk analysis techniques, with discounted cash flow models being the most popular technique. It is not clear if

the latter technique was one of several alternatives offered to the survey participants, but it should be noted that DCF models are not risk analysis techniques *per se*. The survey also found that, although fewer consultants than contractors used quantitative techniques, more consultants (44%) than contractors (18%) undertook computer-based analysis. The discordance between these two findings is not further reported on by Potts and Weston.

The Potts and Weston (1996) survey also explored respondents' perceptions of the importance and likelihood of occurrence of a catalogue of twenty-five project risks. A four-point rating scale (from "high" to "no risk") was used for the importance variable and a three-point scale ("high", "medium" and "low") for the occurrence variable. The researchers multiplied the two respondent rating scores for each risk to arrive at what they termed a *level of risk* or *risk factor*, and compared the top ten risks perceived by the consultants with those of the contractor respondents. Consultants perceived the risks (in decreasing order of importance) as:

1. Client changes (ranked 2 by contractors)
2. Program adequacy (11)
3. Project scope (7)
4. Bureaucratic delay (17)
5. Ground conditions (1)
6. Contractor experience (13)
7. Project organisation (15)
8. Estimating data (equal 17)
9. Labour shortage (4) and
10. Local conditions (not in contractors' list).

Risks perceived by contractors, but not in the top ten of the consultants' list, included: cash flows (equal 4); contract conditions (equal 7); and "funding", which was described as "liaison between several funders" (10). It is not clear if the researchers calculated any risk factors where respondents had assigned an occurrence rating to a "no risk" importance rating, as this combination would not logically be possible. The researchers, perhaps questionably, also assumed that the consultant respondents were reflecting the views of project clients. Interestingly, for consultants the risk of client changes to the project (a legal risk where sanctioned by the conditions of contract) rated nearly twice as high as the risk of estimating data inadequacy (a technical risk).

Their survey revealed that intuition based on experience was overwhelmingly the method most often used by both respondent groups to deal with risk. The main reasons respondents gave for not undertaking formal project risk analysis were: projects not sufficiently large to warrant (*the cost of*) it; lack of information about risk analysis; and lack of time. These findings support those found earlier by Bowen (1993), and tend to support a hypothesis that construction professionals lack a comprehensive understanding of formal decision-making.

Akintoye and MacLeod (1997) used a questionnaire survey to elicit the opinions of 30 contractors and 13 project management consultants about risk perceptions and risk management practices in the United Kingdom. An open-ended question about the meaning of risk produced a wide variety of responses, but most respondents included some reference to the occurrence of adverse events, relating to time, cost or quality, in their descriptions of risk. Respondents were also asked to rate (from "high" to "low") the extent of risk premium they would attach to different risks. For both sub-groups, financial risks rated highest, with legal and economic risks close behind. Adverse weather, a natural risk, was rated lowly by both groups. As far as risk management techniques are concerned, about a third of contractor respondents used risk premiums (contingency allowances); about half used sensitivity analysis; and, while 20% of them knew about Monte Carlo simulation, only 3% ever used it. Project manager respondents were more familiar with probabilistic techniques than contractors, and tended to use them more, but not by an overwhelmingly large degree. This appears to contradict the findings of the Potts and Weston (1996) research of a year earlier. By far the most frequently used ingredients in risk management for both groups were intuition and judgement based on experience, thus leaving their decision-making susceptible to the biases explored by Birnie (1993). Lack of time, lack of appropriate data, lack of familiarity with techniques, questionable relevance of techniques, and the superiority of experience, were all reasons offered by respondents for not making greater use of formal quantitative risk analysis techniques.

Akintoye and Taylor (1997) examined risk prioritisation by clients, contractors and finance organisations in the specific context of the Private Finance Initiative, a policy developed to encourage private sector financing of public projects in the United Kingdom. The questionnaire survey covered 41 respondents holding senior positions in their respective organisations, who were asked to choose from Likert scale ratings for each of twenty-six risks catalogued in the survey instrument. The findings indicated that, despite minor differences in individual rankings, the ten risk factors rated most important by each sub-group were related to: design error, life-cycle costs, project performance, project construction delay, project cost over-run, commissioning delay, project operating income, project operational and maintenance costs, contractor payment

security, and bid preparation costs. The researchers note that theirs is one of the first studies of its kind involving a new and relatively untried procurement method (PFI). The cataloguing of the risks differs from that of Potts and Weston (1996), thus precluding close comparison between the two surveys.

Australian contractors' approaches to risk identification were investigated by Bajaj *et al.* (1997), who surveyed 19 building contractors. They found that, for more than 75% of respondents, pre-tender project risk reviews were entrusted to one or two experienced people in the company. Less than half used a brainstorming approach to identify risks, while just over a half used risk checklists. According to the researchers, risk analysis in this group is generally based upon intuition and experience, and hardly ever on quantitative techniques.

Mok *et al.* (1997) surveyed the risk perceptions and practices of 52 Hong Kong building services consultants. They found that fewer than 30% of respondents possessed a comprehensive understanding of the meaning of risk; and fewer than 20% used probabilistic techniques of risk analysis. More than 75% of respondents most frequently used deterministic single-figure estimates, and more than 85% simply added a contingency sum to allow for risks. Less than 10% of respondents frequently used sensitivity analysis to check the validity of their risk allowances. On the other hand, more than 60% of respondents agreed that the establishment of probabilities constituted an inherent problem in quantitative risk analysis; while more than 50% agreed that interpreting the outcomes of risk analysis was difficult. Flaws in the research instrument design are apparent in the report of this research (Edwards and Bowen, 1997).

Shen (1997) used a postal questionnaire to survey 85 Hong Kong-based contractors who were asked to rate eight construction risks in terms of delays caused to projects. Their ratings were then used as weightings and converted directly into scores to produce a ranked list of factors. The weakness of this approach lies in the researcher's assumption of the validity of the rating scale scoring being sufficiently consistent across the respondent sample. Not surprisingly, contractors ranked risks outside their organisational control (eg. incorrect design information; adverse weather and ground conditions; subcontractor delay; materials/plant resource shortages) more highly than factors for which they could be held directly accountable (eg. poor co-ordination of subcontractors; poor programming; lack of skills; abortive work).

Jackson *et al.* (1997) surveyed the estimating and risk management procedures of 125 professional quantity surveying practices in the UK, and found that few used anything other than contingency allowances based on professional judgement and intuition to deal with estimating risks.

Disinclination to use more sophisticated techniques was attributed to lack of understanding, doubts about their reliability, lack of perceived benefit, cost, and lack of appropriate information technology facilities. These findings support the earlier ones of Bowen (1993), although he found range estimating to be a popular technique among South African quantity surveyors (albeit for dealing with cost data uncertainty rather than explicit risks).

The risk management practices of seventy-four responding quantity surveying, project management and multi-disciplinary practices formed the basis of postal survey questionnaire-based research by Amos and Dent (1997). No inter-group comparisons are offered in their findings. Nearly 30% of respondents indicated that they had no set procedure in terms of risk management, although 34% said they kept some form of risk database for compiling information about current projects. Fewer than half of the respondents used anything other than manually-based analytical techniques (compared with computer-based applications).

Ahmed *et al.* (1999) compared the risk management perceptions of contractors and owners in the Hong Kong construction industry. Their survey focussed on the allocation and ranking of a given catalogue of risks. The responses of 19 contractors and 18 "owners and consultants" were analysed, and the results then generalised to the Hong Kong construction industry. The weaknesses of this survey lie in the assumptions that owner (client) and consultant perceptions would be the same; and that the comparative importance of risks is constant. The survey makes no mention of the fact that the allocation of risk might be influenced by the procurement system selected for the project.

Other important aspects of risk management, such as the risk profiles of project participants, the learning effect of risk experiences on risk attitudes, and the interpersonal communication of risk, have so far received little research attention. Some work has been done, but raises more questions than answers. Greenwood (1997), for example, used organisational behaviour-based assessment questionnaires to explore the risk attitudes of more than 350 managers. She found that the fifteen construction managers (all from the same organisation) in the sample each exhibited low risk (ie. risk aversion) preferences in terms of task, team and individual climates. This result was not found among other groups in the sample, and Greenwood speculates that the construction group may have failed to recognise task risks adequately. McKim (1991) found that contractors may be risk-seeking when bidding, but become risk-averse after their tenders have been accepted (the switch from a "competitive" to a "claims" outlook). This suggests that, contrary to Greenwood's speculation, contractors may be very adept at recognising task risks in a specific construction context.

5.2.2. Limitations of survey-based techniques

The survey-based research publications have been dealt with at some length because they raise several issues of concern. All used basic social science survey techniques, but it is clear that not all the researchers did so to a consistently rigorous standard. Some sample frames were inadequate; as were some response rates, leading in several instances to generalised findings and conclusions which were not sustainable. Little evidence was presented of adequate pilot testing of survey instruments or calibration of rating scales. In some instances questionable data transformations were made in the data analysis, and findings reported which were not supported by the analytical data. It is likely that respondent "questionnaire fatigue" would have occurred in several instances.

Trying to investigate the opinions of even one homogenous group of people is difficult enough. Inter-group comparisons are far harder to explore. Most of the surveys included multiple groups (eg. clients, consultants and contractors) in their sample frames, but few of the analyses attempted cross-tabulations of the responses.

A difficulty for anyone trying to use the findings of the survey-based research is the lack of uniformity in the terminology and categorisation of construction and project risks. While it is unreasonable to expect the use of identical catalogues of risk, few of the surveys adopt even comparably similar approaches. This weakens the opportunities for generalising their findings.

By and large, the work reviewed takes the form of general opinion surveys and lacks reference to specific projects. For example, none of the surveys explore relationships between the type of project, type of participants, and type of risk analysis employed. Construction and project risk and risk management take place in the concrete environment of real projects; as does risk learning. To attempt to explore this from an abstract stance, without reference to specific projects and events, is unlikely to progress knowledge in this field to any substantial degree.

What is also lacking in much of the recent project and construction risk management research is data richness, as well as sound proposals to change current practices - along with evidence that such change might be effective.

5.3. Summary of issues.

While the extant survey research into construction risk and risk management has contributed to the body of knowledge in this field, the lack of robustness in the research methodology has tended to undermine the value of the findings. Specifically, the surveys have been found wanting in terms of issues such as:

- their failure to incorporate the dynamic and temporal nature of risk;
- their poorly argued risk catalogues and choices of risk analysis techniques;
- their failure to explore how risk learning occurs;
- their illogical assumptions that consultants' perceptions are the same as clients' views; and
- their lack of project specificity and consequent lack of data richness.

In the light of the criticism offered in this chapter, it is clear that opinion survey research cannot stand alone as an appropriate technique for research into risk and risk management for construction projects. Nevertheless, it is not without merit. Opinion survey research permits a broad canvassing of the veracity of issues, and can provide the evidence required to justify more microscopic exploration. This leads to consideration of a combination of opinion survey and case-based study as an appropriate research technique.

5.4. Justification of survey and case-based approach.

Artoft (1994) proposes story-telling as a useful communication device for recording risk experiences, and this gives the clue to more appropriate methods for construction risk and risk management research generally. "Story-telling" is simply an intimate synonym for case study. Appropriate case study research could provide a depth and quality of data hitherto unavailable. The direct risk experiences of project participants - the stories preferably told as freshly as possible - on real projects should yield more meaningful information than that obtainable from survey questionnaires alone.

The difference in research method can be illustrated through simple example. Assume that the opinions of clients and contractors are sought with respect to allocating a particular risk under a particular form of building contract. Ideally, random samples of at least 400 clients and 400

contractors, familiar with the type of contract, should be selected. Tests of association could then be made to ascertain whether differences in opinion between the two groups were significant (at some appropriate level). However, obtaining 400 responses from each sample frame is not easy, as most of the reviewed work suggests, and would be very costly. Suppose, then, that only 40 responses from each group (*Group A = clients; Group B = contractors*) are available. To pursue the investigation with this sample response size, it is now necessary to split the responses for each category group into two similarly-sized sub-groups; eg. *Client A1 and A2; Contractor B1 and B2*. Now differences between *A1* and *A2*, and between *B1* and *B2*, can be tested for significance. If a significant difference between *A1* and *A2*, or between *B1* and *B2*, is found, then no significance can be attached to any differences found between the whole groups *A* and *B*.

This example deals only with one question and two category groups. Of the latter, only one group - contractors - could even be regarded as relatively homogenous. The data analysis problems escalate enormously if multiple questions (particularly rating or ranking type questions) are included in the survey instrument and more groups (eg. architects, engineers, quantity surveyors, project managers and sub-contractors) are added to the sample frame. None of the reports of the survey-based opinion research reviewed in this Chapter appear to indicate rigorous data analysis to even the two-category group level suggested above.

Taking the hypothetical example further, it might be presumed that the risk allocation question would have been posed in a particular context, or research objective. Suppose this was to explore the potential impact of such a risk on the outcomes of construction projects. Such an objective would be better accommodated within a case study approach. Notionally, in this instance, four case studies would be desirable:

Case W: Risk allocated, but no occurrence of risk event.

Case X: Risk allocated, with occurrence of risk event.

Case Y: Risk not allocated, but no occurrence of risk event.

Case Z: Risk not allocated, with occurrence of risk event.

Actually, only one case (*Case Z*) need be studied, as it would provide the basis for deducing potential impacts for *Case W* and *Case Y*. *Case X*, although desirable, would simply provide either supporting or contradictory evidence. If this evidence were contradictory, then either the research objectives cannot be fulfilled, or further research questions would arise about the principles of risk allocation.

Given these arguments, finding one case (with the required parameters) would seem to be a better approach to the research task than adopting a complicated opinion-based survey approach. A further bonus might be the opportunity to acquire "rich" data through extended interviews with the participants in the case study project.

Case histories might also be used to test alternative risk management techniques and strategies through simulation. While several of the texts on risk analysis provide case study examples, these are often sanitised or truncated to the point where they simply serve as quantitative vehicles for the authors to demonstrate one particular technique. The effect of applying alternative techniques is rarely explored, and the nature of human involvement is excluded completely. One contrasting example where some of these precepts have been demonstrated is described by Stewart and Fortune (1995), who used the Humber Bridge project in the United Kingdom to exploit the data richness that a "soft systems" approach can provide.

An alternative to historical case studies might be direct and impartial observation on "live" projects. Loosemore *et al.* (1996) point to the potential excitement and challenge of an ethnographic research approach, and Loosemore (1993, 1995) has used the live case study technique to explore the concept of reactive organisations to deal with the occurrence of uncertainty and client risk in construction; noting the critical importance of effective communication processes in mitigating the potential for conflict. In terms of project risk communication, for example, Chapman (1994) notes that: "*For both parties to manage their risks effectively, it may be important to move towards a co-operative shared information approach to management...*". The communication issue has also been raised by Edwards *et al.* (1994) and Bowen (1993, 1995) as being an important and under-researched field in a notoriously fragmented industry which relies on communication between the actors in temporary multi-structure management organisations (Cherns and Bryant, 1984) to produce its project outcomes.

A yet more adventurous approach might be case-based "action research", allowing researchers to observe the effects of their direct interventions in the risk management processes of particular projects. This method, for example, might be the only one suitable for exploring the dissonance suggested by Williams (1997) between the developing management philosophy of "empowerment" (where project decision-making is decentralised to employee groups best positioned to undertake it) and the more traditional centralised power structures of project and risk management.

Given the project stakeholder concept explored in Chapter 4, an alternative approach for exploring the issues of risk management might be through the use of "focus groups". This would involve gathering a group (or groups) of experts in their field, and canvassing their views on specific issues presented to them. The disadvantage of this approach is it lacks a specific project context, since the group members would not be stakeholders on the same project. The focus group would actually represent a very limited survey sample, and might incorporate the researcher's selection biases.

For the research presented here, a combination of opinion survey and case study has been chosen. The survey is designed to allow some of the risk categorisation concepts developed in Chapter 2 to be tested against a broader audience than the relatively narrow perspective of a small focus group or a limited number of case studies. Responses to the survey should also provide guidance for the greater focus and "richness" sought from the case studies.

Mis-matches in project participants' risk perceptions can adversely affect the management processes, and lead to potential conflict. The perceptions may also be transferred as players move on to new projects with different management teams.

Before such issues can be properly explored in an *intra*-project environment, however, it is necessary to ascertain whether, and to what extent, such perceptual differences exist on an inter-disciplinary basis. In other words, do engineers, architects, quantity surveyors, project managers and others hold different views professionally about risk and risk management? The survey research addresses this question. The case study research will investigate to what extent professional views about risk are reflected in the risk management practices actually occurring on specific construction projects.

This section of the thesis has presented a justification for the adoption of a combined opinion survey and case study approach to explore issues of construction project risk management. In one sense, if only one person involved in construction projects were to identify or confirm the existence of a risk management issue, that would justify exploring it further. But the issues themselves are not fundamentally critical to society's well-being (compared, for example, with issues relating to nuclear power generation, to the health effects of passive smoking or to the establishment of drug injection clinics in urban locations). The issues relating to this research are important in the sense of seeking improvement in the management of construction projects generally, but are not concerned with whether or not a project should actually be built.

This lack of criticality about the risk issues brings forth advantages and disadvantages for the research methods used. In the first place, a rigorous application of statistical tests of significance to the survey and case data is not warranted, thus avoiding the need to establish an acceptable level of significance. Since the underlying nature of the data is qualitative, broad measures of data centrality (eg. the mode or median and range values) should suffice for the survey data; while pattern matching should be appropriate for the case data.

Secondly, there is no imperative to exhaustively explore every conceivable aspect of every issue, since the research does not aim to produce a compendium of risk and risk management for construction projects. This allows the focus to be on risks which may be considered more important in terms of their impacts or difficulties of management.

The disadvantage of this approach, which could be thought of as broadly ethnographic (Leedy, 1997) in that it comprises qualitative investigation of particular groups of people (stakeholders) in a specific setting (construction projects), is that it appears to lack the objective precision of more quantitative experimental methods. Findings are likely to be more indicative than conclusive, and may raise further questions rather than produce answers. This criticism must be addressed primarily through careful design of the survey instrument and case study protocol.

To summarise, several methods have been considered for collecting appropriate research data. Of these, an opinion survey of construction professionals is selected to confirm the existence and importance of risk issues tentatively and partially identified through literature review. Subsequently, case studies of real life projects will be used for deeper investigation of selected issues in a relevant context. The underlying paradigm for data collection and analysis in both methods will be qualitative, rather than quantitative.

5.5. Survey instrument design.

A postal survey questionnaire was chosen as the survey research instrument. This decision was made on the basis of the time available for design and administration; simplicity of administration; cost; and the ease of adapting the instrument for use in Australia, Singapore and South Africa. The international aspect of the research was occasioned more by the researcher's knowledge of, and access to, these particular countries, than by a particular theoretical justification. Nevertheless, given the increasing globalisation of construction project procurement, inter-country comparisons may prove useful and informative. All three countries are undergoing change in their procurement systems, in each case from a predominantly conventional architect-led "separated" approach. The

Australian construction industry is turning more and more towards "alliancing" (Walker *et al.*, 2000); while in Singapore the "integrated" design-build system is gaining in popularity (MOM, 1999). The "social imperative" of the "new" South Africa has seen experimentation with various modifications to both "separated" and "integrated" procurement systems. These are intended as a means of lifting the skills of workers, and encouraging the participation, in the formal sector of the construction industry, of building organisations which had previously only worked in the informal sector (Taylor and Norval, 1994).

Two questionnaires were prepared, each comprising twelve questions. One questionnaire was intended for professional consultants, and the other for contractors. The latter questionnaire differed only in the alternatives offered in the first demographic question, which sought to establish respondents' prime vocational discipline. An example of the South African survey questionnaire is included in the **Appendix**.

For Questions 2 to 12, respondents are asked to base their replies on a particular construction project, preferably one at a pre-construction stage, so as to focus upon *ex ante* rather than *post facto* aspects of risk management. Questions 2 to 5 deal with aspects such as project location, project type, procurement system and project value. Questions 6 - 9 explore respondents' risk management approaches to their projects, and their familiarity and experience with the theory and practice of risk management.

A matrix approach is used for Questions 10, 11 and 12, which investigate respondents' opinions about the occurrence, impact and response for a given catalogue of risks. The risk source categories are based upon the classification proposed in Chapter 2 and comprise natural risks, and human risks including social, political, financial, economic, legal, political, managerial and technical risk sources. Examples from the extensive literature on project and construction risk were used to create the catalogue. The time component of risk was deliberately omitted the questionnaire design, as were the dynamic aspects of risk, on the grounds that including these would have added substantially to the complexity of the answer matrix, leading to the danger of "respondent fatigue".

Question 10 asks respondents to choose a likelihood of occurrence (probability) for each catalogued risk. Rather than attempting to determine these probabilities quantitatively, a linguistically-qualitative 5-point Likert scale is offered, based on that given in AS/NZ 4360 (1995). Respondents are asked to choose between **rare** (= exceptional circumstances); **unlikely** (= could occur at some time); **moderate** (= should occur at some time); **likely** (= will probably occur); and **almost certain**

(= expected to occur). This approach was justified by the aim of the research, which is to explore mis-matches in perceptions of risk, and not mathematical probabilities.

A different approach is adopted for Question 11, which seeks opinions about the potential impact of each of the catalogued risks. For this question, six potential impacts are identified (cost over-run; time delay; quality reduction; environmental harm; property damage; injury to people). For each risk, respondents are asked to distribute 30 points among the six impacts; being free to allocate no points to an impact if they wish. This method was designed to allow reasonable exploration of the relative impacts of the catalogued risks. The choice of 30 points as a total was made on the grounds that it provided a rounded figure, yet gave respondents the opportunity (should they wish) to allocate points equally among the alternatives.

The same approach is used for Question 12, which examines respondents' preferred risk responses to the catalogued risks. Here 40 points are available to distribute among eight alternatives (retain; retain but price in bid; reduce impact; reduce likelihood; reduce exposure duration; transfer by insurance; transfer by delegation - e.g. contract or sub-contract clauses; and avoid). The rationale for the 40 point total was the same as that adopted for Question 11.

The questionnaire was fine-tuned through consultation with colleagues and a small pilot survey in Melbourne. This resulted in minor amendments to the wording of the demographic questions, and a major reduction in the risk catalogue for Questions 10, 11 and 12, from thirty-four to seventeen risks - thus halving the matrix size for these questions. This reduced the estimated completion time for the questionnaire to approximately 25 minutes.

5.6. Conclusions.

This chapter has critically discussed the extant survey-based construction risk management research. A more appropriate combination of research techniques – opinion survey questionnaire followed up by focussed case study – has been proposed and justified. The design of the survey instrument has been described. The following chapter deals with the administration of the survey instrument, and the analysis and interpretation of the survey data.

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University of Cape Town

CHAPTER 6

OPINION SURVEY ADMINISTRATION, DATA ANALYSIS AND INTERPRETATION

6.1. Introduction.

This chapter reports on the administration of the opinion survey and presents the analysis and interpretation of the data collected through the survey instrument.

6.2. Survey administration.

Membership lists of professional organisations, together with appropriate sections of the Yellow Pages telephone directory, were used to randomly select and obtain company names and addresses in Australia and South Africa. In Singapore, the questionnaire was administered to a group of 50 mature age part-time university students who were all working in the construction industry.

The response rates are as follows:

	<u>Administered</u>	<u>Received</u>	<u>Response %</u>
Australia	120	28	23%
South Africa	320	46	14%
Singapore	50	16	32%
Total	490	90	18%

In Australia and South Africa, the survey questionnaire was administered by post. In Singapore the questionnaire was administered at the beginning of an evening class with students, with verbal requests for its completion made three times during subsequent classes over the following ten days. No other follow-up procedures were used.

All respondents were invited to reply by post or by fax. The Australian and South African sample groups were given stamped addressed reply envelopes.

6.3. Survey data analysis.

Analysis of the data was carried out using SPSS Version 9.0 statistical software. For the purposes of the research this was limited to descriptive frequency analyses of the data, including cross-tabulation. Further tests of association between the sample category sub-group data were considered to be unnecessary and inappropriate for this research. Such tests are unnecessary because the survey data are not intended to provide "stand alone" conclusive evidence of particular situations; but are used to provide a basis for the subsequent and more intensive case study investigation. More stringent tests of association would also be inappropriate in that it is sufficient to demonstrate that differences can, and do, exist between the perceptions of building professionals. The strength and significance of those differences, however, is more important, in terms of their effect, on an *intra*-project level than upon an *inter*-disciplinary level.

The raw scoring data for Questions 11 and 12 was discarded for seven cases where respondents had failed to ensure correct totals of 30 and 40 respectively for their risk impact and response options.

Presentation of the data analysis is contained in forty-one tables, attached at the end of this Chapter.

Discussion of the data analyses follows in three parts: the demographics of the survey respondents; frequency values and cross-tabulations for respondents' risk management approaches; and frequency values and cross-tabulations for respondents' opinions about the occurrence, impact and response aspects of the risk catalogue items.

6.3.1. Demographics

For consultants, Table 6.1. shows a reasonable spread of occupations (*architects, engineers, quantity surveyors and estimators*), with the exception of the Australian respondents, who comprised only quantity surveyors (predominantly) and architects. A greater spread of occupations was found in the contractor sub-group, which comprised *engineers, quantity surveyors, estimators, project managers, construction managers, and contract administrators*. Responses in the "Other" category included materials suppliers, financial directors, safety officers and purchasing officers. Overall, the spread of respondent occupations is reasonable for the research purpose, with no important group (in terms of the project team) under-represented. Consultants, in their capacity as advisors/agents, are usually assumed to represent clients' views, but the psychological characteristics of risk and risk management preclude this assumption here. Nevertheless, clients were deliberately omitted from this survey on the grounds that their intrinsic heterogeneity would preclude useful observation at this stage of the research. Clients are as diverse in nature as the types of projects they procure, and even

ascertaining a true client "population" is likely to be a near impossibility, as also would be identifying a representative sample. For this reason, client perceptions are more usefully explored in the subsequent case studies.

Table 6.2. reflects the nature of the projects used by respondents in their answers. Here too, a spread of project types was encountered. Numerically, *residential* and *commercial* building projects comprised just over half of the total.

The "*traditional*" form of procurement system (design - tender - construct) was found to be the dominant alternative (Table 6.3.). The separation of participant functions under this system supports the validation of differences encountered in respondents' risk management practices and opinions.

Across all respondent groups, an acceptable spread of project values was found (Table 6.4.).

6.3.2. Risk management approaches

Table 6.5. presents the frequency values for respondents' answers to the series of survey questions relating to their understanding and practice of risk management.

Across all respondents, *personal experience* was found to be by far the most dominant method of identifying project risks. Some use of *historical records*, and *in-house experts*, was reported, especially among the contractor sub-group for the latter method. Little use of *external consultants*, and hardly any use of *publications* or *risk register systems*, was found. Issues arising from this finding, to be explored in subsequent case study research, include:

- (a) What is the nature of the personal experience, and how is it used? (the literature describes it as a source of potential bias in risk assessment).
- (b) How are historical records of project risks established and maintained?

For analysing risks, hardly any differences were found between contractors and consultants. *Intuition* was found to be the most popular approach (63.2% of all contractors, 60.8% of consultants), followed by *brainstorming* (52.6%, 45.1%). Analytical techniques such as *decision/fault trees*, *formal mathematical models*, and *computer simulations* were relatively unpopular. These findings give rise to the following issues:

- (c) Whose intuition is used and how?
- (d) How is brainstorming used in risk analysis?

- (e) Why is little use made of formal mathematical models and computer simulation techniques?

Only 22.2% of all contractors and 24% of all consultants indicated that a formal risk management system had been implemented on their projects. This contrasts with the South African respondents, where 60% of South African contractors, and 62.9% of South African consultants, reported being familiar with the theory of risk management. However, Table 6.5. shows that 77.8% of contractors and 74.3% of consultants in this group indicated that no formal risk management systems had been implemented on their projects. Further, 55.6% of South African contractors, but only 41.2% of South African consultants considered themselves as being experienced in the practice of risk management. The issue that arises is:

- (f) If project participants are familiar with risk management theory, and do have some risk management experience, why are they not fully committed to implementing formal risk management systems on their projects?

The questions about the theory and practice of risk management were addressed only to the South African survey group, as a replacement for the corresponding numbered questions to the Australian group which were not appropriate. The Australian questions asked about familiarity with AS/NZS Standard 3931 (Risk Analysis of Technical Systems) and familiarity with AS/NZS Standard 4360 (Risk Management). The answers to these questions from the Singapore survey group (where an unmodified Australian instrument was administered) were discarded as also being inappropriate and therefore unreliable.

The Australian answers to these questions partly explain why so few respondents reported having implemented formal risk management systems on their projects. Only 6.7% of Australian contractors, and no Australian consultants, were familiar with AS/NZS 3931. Similarly, only 6.7% of Australian contractors, and 20% of Australian consultants, expressed familiarity with AS/NZS 4360. It seems that formal risk management systems have not been implemented because the Australian construction industry is largely unaware of the existence of guidelines for such systems. For South Africa, there are no published guidelines anyway, so that despite some familiarity with theory, and some experience in practice, the construction industry there makes little formal recognition of risk management.

The last part of this section explores instances where differences are found in the data analysis when cross-tabulation of the question factor variables is carried out. Because the cross-tabulation

substantially reduces the sample sub-group sizes, the reliability of this analysis is limited, and only selected findings are discussed here. For this reason, data for "contract administrator", "other occupation" and "multiple occupations" are not considered. The data are presented in Tables 6.6 and 6.7.

Tables 6.6 and 6.7. show the results of cross-tabulation between respondents' occupations (Survey Question 1) and their approach to, and knowledge and practice of, risk management on their projects (Survey Questions 6,7,8 and 9).

For the contractor and consultant groups, all disciplines indicated a strong reliance on *personal experience* as a method of identifying project risks, but less evidence of the use of *historical records* was found (Table 6.6.). Engineers, quantity surveyors and estimators made some use of *in-house experts* to identify risks and, together with the architects, also used *external consultants* to a small extent. Project managers and construction managers signalled more use of these two resources. Little or no use of *published sources of risk identification* or *risk registers* was reported by any discipline except contractors' quantity surveyors. Consultants' estimators (ie. estimating specialists employed in consulting firms), but no other discipline, indicated some use of *risk registers*. These findings confirm the need for further investigation as indicated in issues (a) and (b) above.

For analysing project risks (Table 6.6.), *intuition* was preferred by all disciplines except consultants' estimators. Contractors' engineers, quantity surveyors, project managers, and construction managers, as well as consultants' estimators supported the use of *brain-storming* for this task. Consultant engineers and estimators made more use of *decision/fault tree* risk analysis than other disciplines. Little use of *formal mathematical risk analysis models* and *computer simulation* techniques was reported by any discipline, except for consultant estimators (mathematical models) and consultant engineers (computer simulation). These findings substantiate Issues (c), (d) and (e).

Table 6.7. reveals further anomalies in consultants' knowledge and practice of risk management, and confirms the validity of Issue (f). Just over half the contractors' engineers and the consultants' estimators reported having implemented a formal risk management system for their projects, but only 40% or less of all other disciplines had done so. Between 67% and 86% of South African consulting engineers, quantity surveyors and estimators - but only 30% of consulting architects - reported familiarity with the theory of risk management. However, experience in risk management rose for the consulting architects (40% reporting "yes") but fell substantially for consulting engineers, quantity surveyors and estimators, with only the latter group reporting positively (63% "yes"). For the South African contractors, only estimators, and construction managers indicated familiarity with

the theory, and experience in the practice, of risk management. None of the Australian consultants reported any *familiarity with AS/NZS 3931 (Risk analysis of technical systems)*, and only Australian quantity surveyors reported slight (18%) *familiarity with AS/NZS 4360 (Risk management)*.

6.3.3. The risk catalogues

Tables 6.8 to 6.24 show the survey results relating to respondents' perceptions about the occurrence impact and preferred responses for a given catalogue of risks.

Discussion here focuses mainly on the risk events where inconsistencies arise between respondents' answers, or upon answers that cannot be sustained logically.

For the social risk of *criminal acts* (eg. theft) occurring on site, the main difference found was in the modal value for the likelihood of occurrence (Table 6.8.). For the South African contractors and consultants this was a risk "likely" to occur (AS/NZS 4360 = '*will probably occur*'), whereas for the other national groups the modal value was at worst "moderate" (AS/NZS 4360 = '*should occur at some time*'). Australian contractors ("moderate") were more pessimistic than their consultant colleagues ("unlikely"), whereas for the Singapore group this finding was reversed. The impact of this risk was scored most heavily as project cost over-run and time delay, and the favoured management responses were to transfer the risk by insurance and/or reduce the likelihood (eg. by adding extra security).

Another social risk is that of *substance abuse* on site (eg. workers' performance impaired by drugs or alcohol). Again, South African respondents were more pessimistic about the occurrence of this risk (Table 6.9.: modal value "moderate" for contractors and consultants) than either of the other national groups (modal values "rare" and unlikely"). The main impact of this risk was reckoned to be "injury to people" (accidents arising from altered mental/physical states), but South African contractors also recognised that more often the occurrence of substance abuse would result in lower quality of work. The preferred contractor risk management response was to reduce the likelihood (through prevention/detection programs), while consultants also clearly saw this as a contractor's management problem, opting for transferring the risk contractually.

National contexts again affected responses to the political risk of *negative industrial relations action* occurring on a project. Australian contractors (Table 6.10. "moderate") and consultants ("moderate/likely"), operating in a more mature but perhaps more volatile IR environment, were more pessimistic about the likelihood of this risk occurring than their Singapore ("rare" modal value for contractors and consultants) counterparts whose IR climate is more prescribed and restrictive.

South African contractors ("unlikely") were more optimistic than South African consultants ("moderate"), perhaps reflecting the ambiguity of current IR development there, with sweeping social change in industry more publicised than practised. The impact of this risk was consistently seen as causing time delays to projects, and the risk management response pattern was similar to the previous social risk (contractors opting to reduce the likelihood by appropriate management action; consultants preferring to transfer the risk contractually to contractors).

A modal value of "rare" occurred in all respondent groups for the likelihood of the natural risk of *earthquake occurring* (Table 6.11.) with the most pessimistic choice being "unlikely". Contractors tended to view the direct impact of this risk as "property damage", while consultants chose the subsequent consequence "time delay". Overwhelmingly, the preferred management response to this risk was "transfer by insurance".

Surprisingly, the modal values for the likelihood of *flooding occurring on site* (a natural risk) were generally optimistic (Table 6.12. "rare" for contractors and consultants) across all groups. The range of responses to this factor was also more optimistic than pessimistic (no "almost certain" values were found). The impact of this risk was consistently scored most highly as causing time delay to the project; while transferring the risk by insurance was also consistently the preferred management response.

The risk of *productivity problems* occurring on a project is a management risk. The modal value for its likelihood was similar across all groups (Table 6.13. "moderate") except for South African contractors ("likely"), and the impact was consistently scored most highly as causing time delay to projects. However, while most consultants saw this clearly as a risk to be transferred contractually to contractors, and most contractors preferred to treat it by reducing the likelihood (eg. through careful pre-planning and appropriate control systems), the risk management response most highly scored by Australian contractors was for themselves to transfer the risk contractually. This is a clear reflection of the "pass it on down the line to the sub-contractor" stratagem currently evident in the Australian construction industry.

A similar answer pattern was found for the management risk of *quality assurance problems* occurring on site; the impact in this case being most highly scored as causing reductions in quality (Table 6.14.). The same anomaly in risk management response was found among the Australian contractors, and for this risk also among the Singapore contractors - confirming anecdotal opinion that high levels of sub-contracting are rapidly becoming the norm for construction projects in Singapore.

For the managerial risk of *human resource management problems* the modal likelihood of occurrence value of “unlikely” was found for all contractors, and “moderate” for all consultants (Table 6.15.), suggesting that consultants are more pessimistic in this regard. However, the wide range of answers suggests that local industry conditions play a large part in this risk. Most respondents opted for “time delay” as the direct impact of this risk, and most chose “reduce likelihood” as their preferred risk management response.

Across all respondents, the modal value of “unlikely” was found for the likelihood of occurrence of the technical risks of *design failure* and *equipment or systems failure* (Tables 6.16. and 6.17.). Most respondents saw the direct impact of this risk as “time delay”, and most preferred “transfer contractually” as a risk management response.

The pattern of transferring risks contractually down the supply chain was again found in the data for the economic risks of *materials supply*, *labour supply* and *equipment availability* problems being encountered. Time delay was the dominant impact for these risks (Tables 6.18, 6.19 and 6.20).

For South African contractors, the economic risk of *inflation rising* (Table 6.21.: modal likelihood value: “almost certain”) has almost passed beyond the point of being a risk to becoming a certainty. In contrast, other national groups generally regarded the likelihood of this risk as being at worst “unlikely” or “moderate”. While the most highly scored risk management response was generally found to be that of retaining the risk but pricing it in the tender, Australian and Singapore contractors also saw it as another opportunity to pass on risk contractually down the line.

South African contractors were more pessimistic than other groups about the likelihood of the financial risk of *rises in interest rates* occurring (Table 6.22. modal value: “likely”). This contrasts with the modal value of “unlikely” for the contractor group as a whole; although consultants as a whole were more pessimistic with a modal value of “moderate”. Given a consistent respondent view that the impact of this risk would be project cost overrun, the method generally preferred for treating it was to retain the risk but price for it in the project tender.

Respondents were surprisingly optimistic about the likelihood of occurrence of the financial risk of *payment delay or default* (Table 6.23. modal value “moderate” for all contractors and “unlikely for all consultants). The impact of this risk was largely seen as “cost overrun”. Contractors were prepared to retain this risk but price for it in their bids; while consultants thought that it was prudent

to reduce the likelihood of occurrence (although several thought that the risk should simply be retained (i.e. ignored).

A similar pattern of responses was found for the legal risk of *adverse contract clauses being imposed* (Table 6.24.).

Issues arising from these findings include:

- (g) To what extent do criminal acts constitute a serious risk on construction projects, and to what extent is contractors' pricing influenced by local crime rates?
- (h) To what extent do project occupational health and safety systems address problems of substance abuse on site?
- (i) To what extent is the industrial relations climate considered by contractors in planning and pricing for projects?
- (j) How do contractors deal with natural risks (eg. weather)?
- (k) How effective is the current trend in project procurement systems to transfer more and more risks contractually down the supply chain?
- (l) At what point do the risks of rising inflation or rising interest rates begin to affect project risk allocation and risk management?

Depending upon the nature of the risk "stories" encountered, further light on these issues may be shed by the case study investigations.

The survey responses to the risk catalogue items were also cross-tabulated with respondents' nominated occupations, to explore potential differences between professional disciplines. The data are presented in Tables 6.25 to 6.41.

For the social risk of *criminal acts occurring on site*, the modal value for the likelihood of occurrence was "unlikely" across all occupations (Table 6.25.). The modal value for construction managers, however, was "rare"; while for some engineers it was "almost certain". The direct impact of this risk was generally viewed as causing time delay to the project, although quantity surveyors and estimators also perceived a direct project cost overrun impact. The preferred management responses to this risk were to "transfer it contractually" (architects, estimators and project managers) or to reduce the likelihood of occurrence (engineers, quantity surveyors and construction managers).

Table 6.26. shows the cross-tabulations for the social risk of *substance abuse occurring on site*. Here the modal value for likelihood of occurrence was again "unlikely" across all occupations. Construction managers were more optimistic than other professionals (modal value "rare"); whereas quantity surveyors and some engineers were more pessimistic (modal value "moderate"). The direct impact was mostly seen as causing "injury to people" (engineers, quantity surveyors, and estimators), "quality reduction" (architects and construction managers), or "time delay" (project managers). Architects, estimators and project managers preferred the "transfer contractually" management response option for this risk; while engineers, quantity surveyors and construction managers generally opted for "reduce likelihood".

For the political risk of *industrial relations action* on projects, the cross-tabulation data (Table 6.27.) shows the modal likelihood value for all occupations as "moderate", except for architects and quantity surveyors ("unlikely"). Every occupation agreed that the direct impact of this risk is "time delay" to the project. Architects, engineers, estimators and construction managers preferred to "reduce the likelihood" of the risk, while quantity surveyors and project managers opted for "transfer contractually".

The modal value for all occupations is "rare" for the likelihood of the natural risk of *earthquake* occurring on their projects (Table 6.28.). Architects, engineers, project managers and construction managers chose "property damage" as the main direct impact of this risk; but for quantity surveyors it was "time delay" and for estimators" the impact was "injury to people". Architects, engineers and project managers thought the risk should be "retained" (ie.ignored), but quantity surveyors, estimators and construction managers believed that "transfer by insurance" was the best option. It should be noted that, logically, the least preferred response to this risk should have consistently been "reduce likelihood" (since man cannot control the occurrence of natural risks). While this was the case across all occupations, some irrational answers were detected among individual respondents.

Apart from architects ("unlikely") the survey modal value for the likelihood of the natural risk of *flood* on their projects was "rare" for all other occupations (Table 6.29.). The direct impact of flooding was consistently reported as "time delay" to the project. Architects preferred to "avoid" projects with this risk (impossible?) while engineers believed the risk should be "retained" (ie. ignored) - a possible but perhaps imprudent choice. All other occupations scored "transfer by insurance" as the most appropriate response to this risk. While this is a reasonable risk management response, in that the "rare" likelihood would keep insurance premiums low, the "time delay" impact makes insurance less logical as a response since such loss would be difficult for insurers to price. If the direct impact really is time delay to the project, then a better course of risk management action is

to reduce the impact, eg. by physically protecting the works if flood warnings are given, or by executing critical works during dry seasons. It should then be fairly easy to price for these precautions (or at least their Expected Monetary Value) in the project tender.

The modal value for the likelihood of the managerial risk of *productivity problems* occurring (Table 6.30.) was "moderate" for all occupations except architects ("likely") and construction managers (a tri-modal value was found). "Time delay" was consistently scored as the main direct impact of this risk. As noted earlier, risk management response scoring tended to follow the traditional consultant/contractor culture. Architects, engineers and project managers scored "transfer contractually" highest as a response option. Estimators preferred "reduce likelihood", for example by utilising careful project pre-planning. Construction managers opted for "reduce impact" which might be achieved by having ready access to information on alternative sources for essential resources.

For most occupations, the modal value of the likelihood of the managerial risk of *quality assurance problems* occurring was "moderate" (Table 6.31.), although the modal value for estimators was "likely". The obvious direct impact, across all occupations, was "quality reduction". Risk management response scoring was broadly similar in pattern to the previous management risk of productivity problems

A modal value of "moderate" was found for architects, quantity surveyors and project managers for the likelihood that the managerial risk of *human resource problems* would occur on their projects; while for engineers, and estimators this value was "unlikely" (Table 6.32.). "Time delay" was reported by all occupations as the main direct impact of this risk. Architects and engineers opted for "transfer contractually" as a management response to this risk; while quantity surveyors and estimators preferred "reduce likelihood". Project managers somehow wanted to "reduce exposure duration", and construction managers chose "retain but price in bid". All these choices are correct in a sense, but respondents seemed to have difficulty in establishing the logical primary risk response strategy, which supports the earlier survey finding that construction industry professionals generally lack experience in risk management.

For example, if the potential loss of key technical staff poses a serious human resource management risk to a project; then the obvious response strategy should be to try to reduce the likelihood of this happening. This strategy might then be achieved by adopting tight restrictive contracts for personnel, or by offering inducements which could be offset financially by pricing for them in the tender bid.

For all occupations except estimators ("rare") a modal value of "unlikely" was shown (Table 6.33.) for the likelihood of the technical risk of *design failure* occurring on projects. While construction managers scored "property damage" as the main direct impact of this risk, their view was not shared by other professionals, who mostly saw it as causing "time delay" and "cost overrun". The predominant risk management response was "avoid", although quantity surveyors and project managers saw it more as an opportunity for "contractual transfer" of the risk. In the context of the survey, it should be noted that "avoid" might mean not bidding for the project at all, or re-designing the high risk elements.

The modal value "unlikely" was found for all occupations except project managers ("moderate") for the likelihood of occurrence of the technical risk of *equipment or systems failure* on projects (Table 6.34.). "Time delay" was scored as the most direct impact of this risk by all occupations except construction managers ("cost overrun"). While "transfer contractually" (eg. to equipment specialists) was a logical management response chosen by quantity surveyors and project managers, the choices of other professionals were less easy to explain. It is hard to know why "avoid" should be a preferred option (architects and engineers). Nor is it easy to understand why estimators and construction managers should have selected "transfer by insurance" when such a form of insurance would be difficult to obtain. The logical response strategy here should be to try to reduce the likelihood of occurrence.

Across all occupations, modal values of "unlikely", "moderate" and "likely" (Table 6.35.) were found for the likelihood that the economic risk of *materials supply problems* would occur. This is not surprising, given the universal difficulty economists have with predicting trends or events and the national context for such risks noted earlier. Contrasting with the wide range of likelihood values, the direct impact of this risk was consistently scored as "time delay" across all occupations. Engineers, quantity surveyors, estimators and project managers chose "transfer contractually" as their preferred management response, but to whom would the risk be transferred? Architects and construction managers opted for "reduce likelihood" as a more logical response. For example, if a high risk of materials supply problems is anticipated, then pre-purchasing or arranging for early delivery are ways of minimising the chance that this risk will occur on the project; while trying to bind suppliers into tighter contracts may not be as effective.

A similar range of modal values was shown (Table 6.36.) for the likelihood of occurrence of the economic risk of *labour supply problems*. "Transfer contractually" was the popular management response to this risk (architects, engineers and project managers), although quantity surveyors, estimators and construction managers opted for "retain but price in bid", presumably meaning that

under high risk conditions the anticipated extra cost of enticing and securing labour for the project could be recouped in the tender price.

For architects, engineers, quantity surveyors and construction managers, a modal value of "unlikely" was found for the likelihood of occurrence of the economic risk of *equipment availability problems* on their projects (Table 6.37.). Estimators thought this a "moderate" risk, but for project managers it was found to be "likely". Generally, the findings suggest that the prevailing construction equipment market is seen as being more stable than the construction materials or labour markets. "Time delay" was again consistently scored as the main direct impact of this risk. The preferred management responses were similar to those for the labour supply risk, except that quantity surveyors here opted for "transfer contractually" rather than "retain but price in bid".

Estimators displayed the most ambivalence about the likelihood of occurrence for the economic risk of *inflation rising* (Table 6.38. tri-modal value: "unlikely"/"likely"/"almost certain"). The value for engineers was bi-modal ("unlikely"/"moderate"). For project managers and construction managers the modal value was "unlikely", but for architects and quantity surveyors it was "moderate". "Cost overrun" was consistently viewed as the main direct impact. Most occupations scored "retain but price in bid" as their preferred management response, although architects opted for "reduce impact" and project managers for "transfer contractually".

Theoretically, expectations of the likelihood of occurrence for the economic risk of *inflation rising* should match those for the financial risk, *interest rates rising*, in that the latter generally form part of a government's monetary policy to deal with the former. Comparison between Tables 6.38 and 6.39. show that this is so for all occupations in the survey. Again, "cost overrun" is seen as the main direct impact of rising interest rates by all occupations, but for this risk all occupations, except project managers, opted for "retain but price in bid" as their preferred management response. Project managers opted for "retain", ie. for accepting the risk without reimbursement.

Inflation and interest rate risks are highly contextual. The current economic stability in Australia (winter, 2000), for example, suggests that any increase in inflation or interest rates might be regarded as a risk. By contrast, in South Africa it might well be that only extraordinary increases, beyond a given base trend line of anticipated increases, would be regarded as a risk.

It might be argued that professionals working for contractors would be more pessimistic than consultants about the likelihood of occurrence of the financial risk of *payment delay or default*. The "moderate" modal values for project managers, construction managers and contract administrators

(Table 6.40.) supports this argument, when compared to the "unlikely" modal values for professional engineers and quantity surveyors. The "moderate"/"almost certain" bi-modal value for architects, however, confounds this simple view. All occupations scored "cost overrun" as the main direct impact of this risk. Opinion was divided about an appropriate management response. Architects, quantity surveyors and estimators wanted to "reduce likelihood". Engineers thought the risk should simply be retained (ie. ignored); while project managers and construction managers scored "retain but price in bid" as their preferred response. The latter option is difficult to sustain logically, as it would be almost impossible to know what price to put in. If the risk was thought to be severe, then "avoid" might be the best response (ie. do not bid or go ahead with work on the project). Otherwise, "reduce likelihood", eg. by carrying out credit checks or insisting upon the provision of payment guarantees, seems the appropriate course.

Only quantity surveyors (Table 6.41: modal value "moderate") and, to a certain extent project managers, were relatively pessimistic about the likelihood of the legal risk of *adverse contract clauses* being imposed on their projects. The modal values for all other occupations were at worst "unlikely". Architect saw the main direct impact of this risk as being "time delay", but other occupations saw it more as "cost overrun". Project managers and construction managers preferred "transfer contractually" as a risk management response (ie. passing the risk on down the supply chain). Estimators wanted somehow to reduce the likelihood of occurrence, while quantity surveyors opted for "retain but price in bid". Architects showed support for all three of these response options. Minimal support was shown for "avoid", but if adverse contract clauses are likely to be a serious risk, then not becoming involved with a project has to be a prudent consideration for any party.

6.4. Conclusions.

This survey-based risk perception research has revealed much of interest for risk management in the construction industry. Some findings could have been anticipated, but it has been valuable to confirm them. International differences in risk management perceptions and practices for construction projects could be expected, given the different national economic and cultural environments of Australia, Singapore and South Africa, but the research data have allowed simple relative comparisons to be made. Comparisons between the consultant and contractor data confirm the contractually adversarial culture engrained in the prevailing traditional separated system of building procurement.

The data have also confirmed differences between construction professionals in their perceptions of construction risks and the management of those risks. Again, such differences could be expected, particularly given the diverse range of projects upon which respondents were asked to base their answers. However, the data also revealed inconsistencies and illogicalities in construction professionals' risk management knowledge and practice.

Generally, it would be fair to say that the research findings indicate an international lack of maturity and expertise in risk management in the construction industry. This shortcoming highlights several issues, some of which were previously thought to exist and have now been confirmed by this research. Further survey research would be inappropriate to explore these issues, and case-based *intra-project* investigation is necessary to examine issues such as: the nature of personal risk experience and how it is used intuitively in risk management, and why formal risk management systems are not commonly adopted on construction projects. The following chapter describes the protocol framework for such case studies.

SURVEY DATA ANALYSIS TABLES

University of Cape Town

	ALL COUNTRIES		AUSTRALIA		SOUTH AFRICA		SINGAPORE	
	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants
Frequency % values for respondent's main occupation:								
Architect/Designer	0.0	23.1	0.0	16.7	0.0	27.8	0.0	0.0
Engineer	5.4	19.2	6.3	0.0	0.0	25.0	9.1	25.0
Quantity Surveyor	16.2	40.4	6.3	83.3	30.0	25.0	18.2	50.0
Estimator	13.5	17.3	18.8	0.0	20.0	22.2	0.0	25.0
Project Manager	29.7	0.0	43.8	0.0	0.0	0.0	36.4	0.0
Constr. Manager	16.2	0.0	12.5	0.0	30.0	0.0	9.1	0.0
Contr. Administrator	2.7	0.0	0.0	0.0	10.0	0.0	0.0	0.0
Other	13.5	0.0	6.3	0.0	10.0	0.0	27.3	0.0
Multiple occupa.	2.7	0.0	6.3	0.0	0.0	0.0	0.0	0.0

Table 6.1. Survey statistics: frequency values (%) for occupations of respondents.

	ALL COUNTRIES		AUSTRALIA		SOUTH AFRICA		SINGAPORE	
	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants
Frequency % values for project type:								
Civil engineering	18.4	14.0	12.5	0.0	20.0	20.6	25.0	0.0
Residential	26.4	14.0	18.8	33.3	20.0	5.9	41.7	25.0
Commercial	31.6	28.0	31.3	41.7	40.0	23.5	25.0	25.0
Industrial	2.6	12.0	6.3	0.0	0.0	14.7	0.0	25.0
Health, education	13.2	18.0	25.0	25.0	0.0	17.6	8.3	0.0
Community	5.3	12.0	0.0	0.0	20.0	14.7	0.0	25.0
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Multi-type	2.6	2.0	6.3	0.0	0.0	2.9	0.0	0.0

Table 6.2. Survey statistics: Frequency values (%) for types of respondents' project.

Frequency % values for type of project procurement system:	ALL COUNTRIES		AUSTRALIA		SOUTH AFRICA		SINGAPORE	
	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants
Traditional	66.7	76.5	60.0	63.6	80.0	80.6	63.6	75.0
Design and build	13.9	5.9	20.0	9.1	0.0	5.6	18.2	0.0
Const. Mgmt.	13.9	7.8	20.0	18.2	10.0	5.6	9.1	0.0
Mgmt. Contractor	2.8	7.8	0.0	0.0	0.0	8.3	9.1	25.0
BOOT	2.8	2.0	0.0	9.1	10.0	0.0	0.0	0.0

Table 6.3. Survey statistics: frequency values (%) for type of procurement system for respondents' projects.

Frequency % values for total project value (AUS equivalent):	ALL COUNTRIES		AUSTRALIA		SOUTH AFRICA		SINGAPORE	
	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants
Small < \$1 million	18.9	34.6	13.3	8.3	50.0	47.2	0.0	0.0
Medium \$1-5 million	37.8	25.0	46.7	25.0	20.0	27.8	41.7	0.0
Large \$5-20 million	13.5	17.3	20.0	41.7	10.0	5.6	8.3	50.0
Very Large > \$20 million	29.7	23.1	20.0	25.0	20.0	19.4	50.0	50.0

Table 6.4. Survey statistics: frequency values (%) for total project value of respondents' projects.

	ALL COUNTRIES				AUSTRALIA				SOUTH AFRICA				SINGAPORE			
	Contractors		Consultants		Contractors		Consultants		Contractors		Consultants		Contractors		Consultants	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
1. Frequency % values: different methods of risk identification																
Personal experience	81.6	18.4	88.5	11.5	87.5	12.5	91.7	8.3	80.0	20.0	91.7	8.3	75.0	25.0	50.0	50.0
Historical records	42.1	57.9	42.3	57.7	25.0	75.0	41.7	58.3	50.0	50.0	38.9	61.1	58.3	41.7	75.0	25.0
In-house experts	31.6	68.4	17.3	82.7	37.5	62.5	16.7	83.3	20.0	80.0	16.7	83.3	33.3	66.7	25.0	75.0
External consultants	18.4	81.6	19.2	80.8	18.8	81.2	50.0	50.0	0.0	100	8.3	91.7	33.3	66.7	25.0	75.0
Publications	5.3	94.7	0.0	100	0.0	100	0.0	100	10.0	90.0	0.0	100	8.3	91.7	0.0	100
Risk register system	2.6	97.4	5.8	94.2	6.2	93.8	8.3	91.7	0.0	100	5.6	94.4	0.0	100	0.0	100
Other	13.2	86.8	5.8	94.2	18.8	81.2	8.3	91.7	10.0	90.0	5.6	94.4	8.3	91.7	0.0	100
2. Frequency % values: different approaches to risk analysis																
Intuition	63.2	36.8	60.8	39.2	62.5	37.5	91.7	8.3	70.0	30.0	51.4	48.6	58.3	41.7	50.0	50.0
Brainstorming	52.6	47.4	45.1	54.9	43.8	56.2	50.0	50.0	70.0	30.0	40.0	60.0	50.0	50.0	75.0	25.0
Decision/Fault Tree	23.7	76.3	23.5	76.5	18.8	81.2	16.7	83.3	70.0	30.0	22.9	77.1	25.0	75.0	50.0	50.0
Mathematical model	5.3	94.7	7.8	92.2	0.0	100	0.0	100	0.0	100	8.6	91.4	16.7	83.3	25.0	75.0
Computer simulation	7.9	92.1	13.7	86.3	6.2	93.8	0.0	100	10.0	90.0	20.0	80.0	8.3	91.7	0.0	100
Other	10.5	89.5	2.0	98.0	18.8	81.2	0.0	100	10.0	90.0	2.9	97.1	0.0	100	0.0	100
3. Frequency % values: whether or not a formal risk management system has been implemented	22.2	77.8	24.0	76.0	20.0	80.0	9.1	90.9	22.2	77.8	25.7	74.3	25.0	75.0	50.0	50.0
4. Frequency % values: familiarity with theory of risk management	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a	60.0	40.0	62.9	37.1	N/a	N/a	N/a	N/a
5. Frequency % values: experience in practice of risk management	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a	55.6	44.4	41.2	58.6	N/a	N/a	N/a	N/a
6. Frequency % values: familiarity with AS/NZS 3931	N/a	N/a	N/a	N/a	6.7	93.3	0.0	100	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a
7. Frequency % values: familiarity with AS/NZS 4360	N/a	N/a	N/a	N/a	6.7	93.3	20.0	80.0	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a

Table 6.5. Survey statistics: frequency values (%) for respondents' risk management approaches.

	Method of Risk Identification					Technique for Risk Analysis					
	Personal experience % Yes	Historical records % Yes	In-house experts % Yes	External consultants % Yes	Construction publications % Yes	Risk register % Yes	Intuition % Yes	Brain-storming % Yes	Decision/ Fault tree % Yes	Mathematical model % Yes	Computer simulation % yes
ALL CONTRACTORS											
1. Engineers	50.0	100.0	0.0	5.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
2. Quantity surveyors	100.0	33.3	16.7	0.0	16.7	0.0	83.3	66.7	0.0	0.0	0.0
3. Estimators	80.0	60.0	20.0	0.0	0.0	0.0	80.0	40.0	20.0	0.0	0.0
4. Project managers	81.8	36.3	54.5	36.4	0.0	0.0	72.7	54.5	27.3	0.0	9.1
5. Construction managers	83.3	50.0	50.0	16.7	0.0	0.0	83.3	66.7	16.7	0.0	0.0
ALL CONSULTANTS											
1. Architects	91.7	25.0	0.0	16.7	0.0	0.0	63.6	54.5	9.1	0.0	9.1
2. Engineers	90.0	20.0	20.0	10.0	0.0	0.0	50.0	20.0	40.0	0.0	30.0
3. Quantity surveyors	85.7	52.4	23.8	28.6	0.0	4.8	76.2	42.9	19.0	9.5	9.5
4. Estimators	88.9	66.7	22.2	11.1	0.0	22.2	33.3	66.7	33.3	22.2	11.1

Table 6.6. Survey statistics: cross-tabulations for respondent occupation and risk management approach.

	Formal Risk Management System implemented % Yes	Familiar with theory of Risk Management* % Yes	Experienced in practice of Risk Management* % Yes	Familiar with AS/NZS 3931** % Yes	Familiar with AS/NZS 4360** % Yes
ALL CONTRACTORS					
1. Engineers	50.0	N/a	N/a	0.0	0.0
2. Quantity surveyors	0.0	0.0	0.0	0.0	0.0
3. Estimators	40.0	100.0	100.0	0.0	0.0
4. Project managers	30.0	N/a	N/a	0.0	0.0
5. Construction managers	20.0	66.7	66.7	0.0	0.0
ALL CONSULTANTS					
1. Architects	27.3	30.0	40.0	0.0	0.0
2. Engineers	22.2	78.0	37.0	0.0	0.0
3. Quantity surveyors	9.5	67.0	25.0	0.0	18.0
4. Estimators	55.6	86.0	63.0	0.0	0.0

*South African sub-group only **Australian sub-group only

Table 6.7. Survey statistics: cross-tabulations for respondent occupation and risk management knowledge and practice.

	ALL COUNTRIES		AUSTRALIA		SOUTH AFRICA		SINGAPORE	
	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants
1. Modal value for risk likelihood.	Unlikely	Unlikely/Moderate	Moderate	Unlikely	Likely	Likely	Unlikely	Moderate
2. Range of risk likelihood values encountered.	Rare: Almost certain	Rare: Almost certain	Rare: Likely	Rare: Almost certain	Rare: Almost certain	Rare: Almost certain	Rare: Likely	Unlikely: Moderate
3. Risk impact type with greatest mean assigned value.	Cost over-run - Time delay	Time delay	Property damage	Time delay	Cost over-run	Time delay	Time delay	Time delay
4. Risk impact type with least mean assigned value.	Environmental harm	Environmental harm	Injury to people	Environmental harm	Environmental harm	Environmental harm	Environmental harm/ Injury to people	Environmental harm
5. Preferred risk response type with greatest mean assigned value.	Reduce likelihood - Transfer by insurance	Transfer by insurance	Transfer by insurance - Reduce likelihood	Transfer by insurance	Reduce likelihood	Transfer by insurance	Transfer by insurance - Transfer contractually	Transfer contractually
6. Preferred risk response type with least mean assigned value.	Avoid	Retain	Avoid	Retain	Avoid	Retain	Avoid	Avoid

Key: xx/yy: equal values; xx - yy: second value close to first; xx: yy: range of values encountered.

Table 6.8. Survey statistics: social risk of criminal acts.

	ALL COUNTRIES		AUSTRALIA		SOUTH AFRICA		SINGAPORE	
	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants
1. Modal value for risk likelihood.	Unlikely	Unlikely	Unlikely	Unlikely	Moderate	Moderate	Unlikely	Rare/Unlikely
2. Range of risk likelihood values encountered.	Rare: Likely	Rare: Almost certain	Rare: Moderate	Rare: Likely	Unlikely: Likely	Rare: Almost certain	Rare: Likely	Rare: Unlikely
3. Risk impact type with greatest mean assigned value.	Injury to people	Injury to people	Injury to people	Injury to people	Quality reduction - injury to people	Injury to people	Time delay - Quality reduction	Injury to people
4. Risk impact type with least mean assigned value.	Environmental harm	Cost overrun	Environmental harm	Cost overrun	Environmental harm	Cost overrun	Environmental harm	Cost overrun
5. Preferred risk response type with greatest mean assigned value.	Reduce likelihood	Transfer contractually	Transfer contractually - Reduce likelihood	Transfer contractually - Reduce likelihood	Reduce likelihood	Transfer contractually - Reduce likelihood	Reduce likelihood	Transfer contractually
6. Preferred risk response type with least mean assigned value.	Avoid	Retain but price in bid	Avoid	Retain but price in bid	Avoid	Retain but price in bid	Avoid	Avoid

Key: xx/yy: equal values; xx - yy: second value close to first; xx: yy: range of values encountered.

Table 6.9. Survey statistics: social risk of substance abuse on site.

	ALL COUNTRIES		AUSTRALIA		SOUTH AFRICA		SINGAPORE	
	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants
1. Modal value for risk likelihood.	Moderate	Moderate	Moderate	Moderate/Likely	Unlikely	Moderate	Rare	Rare
2. Range of risk likelihood values encountered.	Rare: Almost certain	Rare: Almost certain	Rare: Almost certain	Rare: Almost certain	Rare: Likely	Rare: Almost certain	Rare: Likely	Rare
3. Risk impact type with greatest mean assigned value.	Time delay	Time delay	Time delay	Time delay	Time delay	Time delay	Time delay	Time delay
4. Risk impact type with least mean assigned value.	Environmental harm	Environmental harm	Environmental harm	Environmental harm - Property damage	Environmental harm	Environmental harm	Injury to people	Environmental harm
5. Preferred risk response type with greatest mean assigned value.	Reduce likelihood	Transfer contractually	Reduce likelihood	Transfer contractually	Reduce likelihood	Reduce likelihood Transfer contractually	Retain - Transfer contractually	Transfer contractually
6. Preferred risk response type with least mean assigned value.	Avoid	Retain	Transfer by insurance	Retain	Avoid	Retain	Reduce exposure duration - Retain but price in bid	Retain

Key: xx/yy: equal values; xx - yy: second value close to first; xx: yy: range of values encountered.

Table 6.10. Survey statistics: political risk of negative industrial relations action.

	ALL COUNTRIES		AUSTRALIA		SOUTH AFRICA		SINGAPORE	
	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants
1. Modal value for risk likelihood.	Rare	Rare	Rare	Rare	Rare	Rare	Rare	Rare
2. Range of risk likelihood values encountered.	Rare: Unlikely	Rare: Unlikely	Rare	Rare: Unlikely	Rare: Unlikely	Rare: Unlikely	Rare	Rare
3. Risk impact type with greatest mean assigned value.	Property damage	Time delay	Property damage	Time delay	Cost overrun - Time delay	Time delay	Property damage Injury to people	Injury to people Time delay
4. Risk impact type with least mean assigned value.	Quality reduction	Quality reduction	Environmental harm	Quality reduction	Quality reduction	Quality reduction	Quality reduction	Quality reduction/ Environmental harm
5. Preferred risk response type with greatest mean assigned value.	Transfer by insurance	Transfer by insurance	Retain	Transfer by insurance	Transfer by insurance	Transfer by insurance - Retain	Retain - Transfer by insurance	Transfer contractually
6. Preferred risk response type with least mean assigned value.	Reduce likelihood	Reduce impact	Reduce likelihood	Reduce impact	Avoid	Reduce likelihood/Reduce exposure duration	Reduce exposure duration	Reduce exposure duration/Avoid

Key: xx/yy: equal values; xx - yy: second value close to first; xx: yy: range of values encountered.

Table 6.11. Survey statistics: natural risk of earthquake occurring.

	ALL COUNTRIES		AUSTRALIA		SOUTH AFRICA		SINGAPORE	
	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants
1. Modal value for risk likelihood.	Rare	Rare	Rare	Rare	Unlikely	Rare	Rare	Unlikely
2. Range of risk likelihood values encountered.	Rare: Likely	Rare: Moderate	Rare: Likely	Rare: Unlikely	Rare: Unlikely	Rare: Moderate	Rare: Moderate	Rare: Unlikely
3. Risk impact type with greatest mean assigned value.	Time delay	Time delay	Time delay - Property damage	Time delay	Time delay - Cost overrun	Time delay	Time delay	Time delay
4. Risk impact type with least mean assigned value.	Quality reduction	Quality reduction	Quality reduction	Quality reduction	Injury to people	Quality reduction	Quality reduction	Quality reduction/ Property damage
5. Preferred risk response type with greatest mean assigned value.	Transfer by insurance	Transfer by insurance	Retain	Transfer by insurance	Transfer by insurance	Transfer by insurance	Transfer by insurance	Transfer contractually
6. Preferred risk response type with least mean assigned value.	Reduce likelihood	Reduce exposure duration	Reduce likelihood	Retain but price in bid	Avoid/ Retain but price in bid	Reduce exposure duration	Reduce exposure duration	Retain

Key: xx/yy: equal values; xx - yy: second value close to first; xx: yy: range of values encountered.

Table 6.12. Survey statistics: natural risk of flood occurring.

	ALL COUNTRIES		AUSTRALIA		SOUTH AFRICA		SINGAPORE	
	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants
1. Modal value for risk likelihood.	Moderate	Moderate	Moderate	Moderate	Likely	Moderate	Moderate	Moderate
2. Range of risk likelihood values encountered.	Unlikely: Almost certain	Rare: Almost certain	Unlikely: Almost certain	Rare: Almost certain	Unlikely: Almost certain	Unlikely: Almost certain	Unlikely: Almost certain	Moderate
3. Risk impact type with greatest mean assigned value.	Time delay	Time delay	Time delay	Time delay – cost overrun	Time delay/Cost overrun	Time delay	Time delay	Time delay
4. Risk impact type with least mean assigned value.	Injury to people	Injury to people	Environmental harm	Injury to people	Injury to people/property damage/ Environmental harm	Injury to people	Injury to people	Environmental harm/ Property damage/ Injury to people
5. Preferred risk response type with greatest mean assigned value.	Reduce likelihood	Transfer contractually -Reduce likelihood	Transfer contractually	Retain	Reduce likelihood	Reduce likelihood – Transfer contractually	Reduce likelihood	Transfer contractually
6. Preferred risk response type with least mean assigned value.	Transfer by insurance	Transfer by insurance	Transfer by insurance	Transfer by insurance	Transfer by insurance	Avoid	Transfer by insurance	Transfer by insurance

Key: xx/yy: equal values; xx – yy: second value close to first; xx: yy: range of values encountered.

Table 6.13. Survey statistics: managerial risk of productivity problems.

	ALL COUNTRIES		AUSTRALIA		SOUTH AFRICA		SINGAPORE	
	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants
1. Modal value for risk likelihood.	Moderate	Moderate	Moderate	Moderate/Likely	Likely	Moderate	Moderate	Moderate/ Likely
2. Range of risk likelihood values encountered.	Rare: Almost certain	Rare: Almost certain	Unlikely: Almost certain	Rare: Likely	Rare: Likely	Rare: Almost certain	Unlikely: Almost certain	Moderate/ Likely
3. Risk impact type with greatest mean assigned value.	Quality reduction	Quality reduction	Quality reduction	Quality reduction	Quality reduction	Quality reduction	Quality reduction	Quality reduction
4. Risk impact type with least mean assigned value.	Property damage	Property damage	Property damage	Environmental harm/Property damage	Injury to people/Property damage/Env. harm	Injury to people	Environmental harm	Environmental harm/ Property damage
5. Preferred risk response type with greatest mean assigned value.	Reduce likelihood – Transfer contractually	Reduce likelihood	Transfer contractually – Reduce likelihood	Transfer contractually – Reduce likelihood	Reduce likelihood	Reduce likelihood	Transfer contractually	Transfer contractually – Reduce likelihood
6. Preferred risk response type with least mean assigned value.	Retain	Transfer by insurance	Transfer by insurance	Transfer by insurance	Transfer by insurance	Transfer by insurance	Retain	Transfer by insurance

Key: xx/yy: equal values; xx – yy: second value close to first; xx: yy: range of values encountered

Table 6.14. Survey statistics: managerial risk of quality assurance problems.

	ALL COUNTRIES		AUSTRALIA		SOUTH AFRICA		SINGAPORE	
	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants
1. Modal value for risk likelihood.	Unlikely	Moderate	Unlikely	Moderate	Unlikely	Moderate	Moderate	Unlikely
2. Range of risk likelihood values encountered.	Rare: Almost certain	Rare: Almost certain	Rare: Almost certain	Rare: Almost certain	Rare: Moderate	Rare: Almost certain	Unlikely: Likely	Unlikely: Moderate
3. Risk impact type with greatest mean assigned value.	Time delay	Time delay	Quality reduction – Time delay	Time delay	Time delay	Time delay	Time delay	Time delay
4. Risk impact type with least mean assigned value.	Property damage	Injury to people	Property damage	Injury to people	Injury to people/Property damage/Env. harm	Injury to people	Property damage	Environmental harm/Property damage
5. Preferred risk response type with greatest mean assigned value.	Reduce likelihood	Reduce likelihood – Transfer contractually	Reduce impact	Retain but price in bid	Reduce likelihood	Reduce likelihood	Reduce likelihood	Transfer contractually
6. Preferred risk response type with least mean assigned value.	Transfer by insurance	Avoid	Transfer by insurance	Avoid	Transfer by insurance/Avoid	Avoid	Retain but price in bid	Avoid

Key: xx/yy: equal values; xx – yy: second value close to first; xx: yy: range of values encountered

Table 6.15. Survey statistics: managerial risk of human resource management problems.

	ALL COUNTRIES		AUSTRALIA		SOUTH AFRICA		SINGAPORE	
	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants
1. Modal value for risk likelihood.	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely	Moderate	Unlikely
2. Range of risk likelihood values encountered.	Rare: Almost certain	Rare: Likely	Rare: Moderate	Rare: Likely	Rare: Moderate	Rare: Likely	Rare: Almost certain	Rare: Unlikely
3. Risk impact type with greatest mean assigned value.	Cost overrun - Time delay	Time delay	Cost overrun	Time delay	Time delay	Time delay	Time delay - Cost overrun	Time delay
4. Risk impact type with least mean assigned value.	Environmental harm	Environmental harm	Environmental harm	Environmental harm	Environmental harm	Environmental harm	Environmental harm	Environmental harm
5. Preferred risk response type with greatest mean assigned value.	Transfer contractually	Avoid	Transfer contractually	Avoid	Transfer by insurance - Transfer contractually	Avoid	Transfer contractually	Reduce Likelihood - Transfer contractually
6. Preferred risk response type with least mean assigned value.	Reduce exposure duration	Reduce exposure duration	Reduce exposure duration	Reduce exposure duration	Reduce exposure duration	Retain but price in bid	Reduce exposure duration	Retain

Key: xx/yy: equal values; xx - yy: second value close to first; xx: yy: range of values encountered.

Table 6.16. Survey statistics: technical risk of design failure.

	ALL COUNTRIES		AUSTRALIA		SOUTH AFRICA		SINGAPORE	
	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants
1. Modal value for risk likelihood.	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely	Moderate	Unlikely
2. Range of risk likelihood values encountered.	Rare: Almost certain	Rare: Likely	Rare: Likely	Rare: Moderate	Rare: Moderate	Rare: Moderate	Rare: Almost certain	Unlikely: Likely
3. Risk impact type with greatest mean assigned value.	Time delay	Time delay	Time delay	Time delay	Cost overrun	Time delay	Time delay	Time delay
4. Risk impact type with least mean assigned value.	Environmental harm	Environmental harm	Environmental harm	Environmental harm	Environmental harm	Environmental harm	Environmental harm	Environmental harm
5. Preferred risk response type with greatest mean assigned value.	Transfer contractually	Transfer contractually	Transfer contractually - Reduce likelihood	Transfer contractually	Reduce likelihood - Transfer contractually	Avoid - Reduce likelihood	Transfer contractually	Reduce likelihood
6. Preferred risk response type with least mean assigned value.	Reduce exposure duration	Retain but price in bid - Reduce exposure duration	Reduce exposure duration	Transfer by insurance	Retain	Retain but price in bid	Reduce exposure duration	Retain

Key: xx/yy: equal values; xx - yy: second value close to first; xx: yy: range of values encountered.

Table 6.17. Survey statistics: technical risk of equipment or system failure.

	ALL COUNTRIES		AUSTRALIA		SOUTH AFRICA		SINGAPORE	
	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants
1. Modal value for risk likelihood.	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Unlikely	Moderate
2. Range of risk likelihood values encountered.	Rare: Almost certain	Rare: Almost certain	Rare: Almost certain	Rare: Moderate	Rare: Moderate	Rare: Almost certain	Unlikely: Likely	Unlikely: Likely
3. Risk impact type with greatest mean assigned value	Time delay	Time delay	Time delay	Time delay	Time delay	Time delay	Time delay	Time delay Cost overrun
4. Risk impact type with least mean assigned value.	Property damage - Injury to people	Injury to people - Property damage	Property damage/ Injury to people	Property damage/ Injury to people	Environmental harm/Property damage/ Injury to people	Injury to people	Environmental harm/ Property damage	Damage to property/ Injury to people
5. Preferred risk response type with greatest mean assigned value.	Transfer contractually	Transfer contractually	Transfer contractually	Transfer contractually	Reduce likelihood	Transfer contractually - Reduce likelihood	Transfer contractually	Transfer contractually
6. Preferred risk response type with least mean assigned value.	Retain	Transfer by insurance	Retain	Transfer by insurance	Avoid/Transfer by insurance	Transfer by insurance	Retain	Retain

Key: xx/yy: equal values; xx - yy: second value close to first; xx: yy: range of values encountered.

Table 6.18. Survey statistics: economic risk of materials supply problems.

	ALL COUNTRIES		AUSTRALIA		SOUTH AFRICA		SINGAPORE	
	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants
1. Modal value for risk likelihood.	Moderate	Moderate	Moderate	Moderate	Unlikely	Moderate	Moderate/Likely	Unlikely/ Moderate/ Likely/ Almost certain
2. Range of risk likelihood values encountered.	Rare: Almost certain	Rare: Almost certain	Rare: Almost certain	Rare: Likely	Rare: Likely	Rare: Almost certain	Unlikely: Likely	Unlikely: Almost certain
3. Risk impact type with greatest mean assigned value.	Time delay	Time delay	Time delay	Time delay	Time delay	Time delay	Time delay	Time delay – Cost overrun
4. Risk impact type with least mean assigned value.	Environmental harm	Property damage – Environmental harm	Environmental harm	Environmental harm/Property damage	Environmental harm/Property damage/Injury to people	Environmental harm/Property damage	Environmental harm/Injury to people	Property damage
5. Preferred risk response type with greatest mean assigned value.	Retain but price in bid – Reduce likelihood - Transfer contractually	Transfer contractually	Retain but price in bid	Transfer contractually – Retain but price in bid	Reduce likelihood	Transfer contractually	Transfer contractually	Transfer contractually
6. Preferred risk response type with least mean assigned value.	Avoid	Retain but price in bid	Avoid	Transfer by insurance	Avoid/Transfer by insurance	Avoid	Reduce exposure duration	Avoid

Key: xx/yy: equal values; xx – yy: second value close to first; xx: yy: range of values encountered.

Table 6.19. Survey statistics: economic risk of labour supply problems.

	ALL COUNTRIES		AUSTRALIA		SOUTH AFRICA		SINGAPORE	
	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants
1. Modal value for risk likelihood.	Unlikely	Unlikely	Unlikely	Moderate	Unlikely	Unlikely	Unlikely	Unlikely
2. Range of risk likelihood values encountered.	Rare: Likely	Rare: Likely	Rare: Likely	Rare: Likely	Rare: Likely	Rare: Likely	Unlikely: Likely	Unlikely: Moderate
3. Risk impact type with greatest mean assigned value.	Time delay	Time delay	Time delay	Time delay	Time delay	Time delay	Time delay	Cost overrun - Time delay
4. Risk impact type with least mean assigned value.	Environmental harm	Environmental harm	Environmental harm	Environmental harm	Environmental harm/Property damage/Injury to people	Injury to people	Property damage	Environmental harm/ Property damage
5. Preferred risk response type with greatest mean assigned value.	Transfer contractually - Retain but price in bid	Transfer contractually	Retain but price in bid - Transfer contractually	Transfer contractually - Retain	Reduce likelihood	Transfer contractually	Transfer contractually	Retain but price in bid
6. Preferred risk response type with least mean assigned value.	Transfer by insurance	Transfer by insurance	Transfer by insurance	Transfer by insurance	Avoid/Transfer by insurance	Transfer by insurance	Transfer by insurance	Retain

Key: xx/yy: equal values; xx - yy: second value close to first; xx: yy: range of values encountered.

Table 6.20. Survey statistics: economic risk of equipment availability problems.

	ALL COUNTRIES		AUSTRALIA		SOUTH AFRICA		SINGAPORE	
	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants
1. Modal value for risk likelihood.	Unlikely	Moderate	Unlikely	Unlikely	Almost certain	Moderate	Unlikely	Moderate
2. Range of risk likelihood values encountered.	Rare: Almost certain	Rare: Almost certain	Rare: Almost certain	Rare: Moderate	Rare: Almost certain	Rare: Almost certain	Unlikely: Likely	Unlikely: Likely
3. Risk impact type with greatest mean assigned value.	Cost overrun	Cost overrun	Cost overrun	Cost overrun	Cost overrun	Cost overrun	Cost overrun	Cost overrun – Time delay
4. Risk impact type with least mean assigned value.	Property damage	Property damage/ Injury to people	Property damage/ Injury to people	Environmental harm/ Property damage/ Injury to people	Environmental harm/ Property damage/ Injury to people	Property damage/ Injury to people	Property damage	Environmental harm/ Property damage/ Injury to people
5. Preferred risk response type with greatest mean assigned value.	Retain but price in bid	Retain but price in bid	Transfer contractually - Retain	Transfer contractually – Retain but price in bid	Retain but price in bid	Reduce impact – Retain but price in bid	Transfer contractually – Retain but price in bid	Retain but price in bid
6. Preferred risk response type with least mean assigned value.	Transfer by insurance	Avoid	Transfer by insurance	Transfer by insurance	Retain/Avoid	Avoid	Reduce likelihood	Retain/Avoid

Key: xx/yy: equal values; xx – yy: second value close to first; xx: yy: range of values encountered.

Table 6.21. Survey statistics: economic risk of inflation rising.

	ALL COUNTRIES		AUSTRALIA		SOUTH AFRICA		SINGAPORE	
	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants
1. Modal value for risk likelihood.	Unlikely	Moderate	Unlikely	Unlikely	Likely	Moderate	Unlikely	Moderate
2. Range of risk likelihood values encountered.	Rare: Almost certain	Rare: Almost certain	Rare: Almost certain	Rare: Moderate	Unlikely: Almost certain	Rare: Almost certain	Unlikely: Likely	Unlikely: Likely
3. Risk impact type with greatest mean assigned value.	Cost overrun	Cost overrun	Cost overrun	Cost overrun	Cost overrun	Cost overrun	Cost overrun	Cost overrun
4. Risk impact type with least mean assigned value.	Property damage	Property damage/Injury to people	Property damage/Injury to people	Environmental harm/Property damage/Injury to people	Environmental harm/Property damage/Injury to people	Property damage/Injury to people	Property damage	Environmental harm
5. Preferred risk response type with greatest mean assigned value.	Retain but price in bid	Retain but price in bid	Retain – Retain but price in bid	Transfer contractually – Retain but price in bid	Retain but price in bid	Retain but price in bid	Retain but price in bid – Transfer contractually	Retain but price in bid
6. Preferred risk response type with least mean assigned value.	Transfer by insurance	Avoid	Transfer by insurance	Transfer by insurance	Retain/Avoid	Avoid	Transfer by insurance/Avoid	Retain/Avoid

Key: xx/yy: equal values; xx – yy: second value close to first; xx: yy: range of values encountered.

Table 6.22. Survey statistics: financial risk of interest rates rising.

	ALL COUNTRIES		AUSTRALIA		SOUTH AFRICA		SINGAPORE	
	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants
1. Modal value for risk likelihood.	Moderate	Unlikely	Moderate	Unlikely	Moderate	Unlikely	Moderate/Likely	Moderate
2. Range of risk likelihood values encountered.	Rare: Almost certain	Rare: Almost certain	Rare: Almost certain	Rare: Moderate	Unlikely: Likely	Rare: Almost certain	Rare: Almost certain	Unlikely: Moderate
3. Risk impact type with greatest mean assigned value.	Cost overrun	Cost overrun	Cost overrun	Cost overrun	Cost overrun – time delay	Cost overrun	Cost overrun	Cost overrun
4. Risk impact type with least mean assigned value.	Property damage	Environmental harm/Injury to people	Environmental harm/Property damage/Injury to people	Injury to people	Environmental harm/Property damage/Injury to people	Environmental harm	Property damage	Property damage/Injury to people
5. Preferred risk response type with greatest mean assigned value.	Retain but price in bid/Reduce likelihood	Reduce likelihood/Retain	Retain but price in bid	Reduce likelihood	Retain but price in bid	Retain	Reduce likelihood	Reduce likelihood
6. Preferred risk response type with least mean assigned value.	Retain	Transfer by insurance	Transfer by insurance	Transfer by insurance	Retain	Transfer by insurance	Transfer by insurance	Avoid

Key: xx/yy: equal values; xx – yy: second value close to first; xx: yy: range of values encountered.

Table 6.23. Survey statistics: financial risk of payment delay or default.

	ALL COUNTRIES		AUSTRALIA		SOUTH AFRICA		SINGAPORE	
	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants	Contractors	Consultants
1. Modal value for risk likelihood.	Moderate	Unlikely	Unlikely	Moderate	Rare/Unlikely/ Moderate/Likely	Unlikely	Moderate	Likely
2. Range of risk likelihood values encountered.	Rare: Almost certain	Rare: Almost certain	Rare: Almost certain	Rare: Almost certain	Rare: Likely	Rare: Almost certain	Unlikely: Likely	Rare: Likely
3. Risk impact type with greatest mean assigned value.	Cost overrun	Cost overrun / Time delay	Cost overrun	Cost overrun	Cost overrun	Cost overrun / Time delay	Cost overrun / Time delay	Cost overrun
4. Risk impact type with least mean assigned value.	Environmental harm	Environmental harm – Injury to people	Environmental harm	Property damage/ Injury to people	Environmental harm/Property damage/Injury to people	Environmental harm/ Injury to people	Environmental harm/Property damage/Injury to people	Environmental harm
5. Preferred risk response type with greatest mean assigned value.	Retain but price in bid	Retain but price in bid	Retain but price in bid	Transfer contractually – Retain but price in bid	Retain but price in bid – Reduce likelihood -Transfer contractually	Retain but price in bid/ Reduce likelihood	Transfer contractually – Retain but price in bid	Transfer contractually
6. Preferred risk response type with least mean assigned value.	Retain	Reduce exposure duration	Avoid/Retain	Reduce impact	Retain/Transfer by insurance	Reduce exposure duration	Retain	Retain

Key: xx/yy: equal values; xx – yy: second value close to first; xx: yy: range of values encountered.

Table 6.24. Survey statistics: legal risk of adverse contract clauses being imposed.

	Architects	Engineers	Quantity Surveyors	Estimators	Project Managers	Construction Managers	All Occupations
1. Modal value for risk likelihood.	Moderate	Unlikely/ Moderate/ Almost certain	Unlikely	Moderate	Unlikely	Rare	Unlikely
2. Range of risk likelihood values encountered.	Rare: Almost certain	Rare: Almost certain	Rare: Almost certain	Rare: Almost certain	Rare: Moderate	Rare: Almost certain	Rare: Almost certain
3. Risk impact type with greatest mean assigned value.	Time delay	Time delay	Cost overrun - Time delay	Cost overrun - Time delay	Time delay	Time delay	Time delay - Cost overrun
4. Risk impact type with least mean assigned value.	Environmental harm	Environmental harm	Environmental harm	Environmental harm	Environmental harm	Environmental harm	Environmental harm
5. Preferred risk response type with greatest mean assigned value.	Transfer by insurance	Transfer by insurance - Transfer contractually	Transfer by insurance	Transfer by insurance	Reduce likelihood - Transfer contractually	Reduce likelihood/ Transfer by insurance/ Transfer contractually	Transfer by insurance
6. Preferred risk response type with least mean assigned value.	Avoid	Retain	Avoid	Retain	Avoid	Avoid	Avoid

Key: xx/yy: equal values; xx – yy: second value close to first; xx: yy: range of values encountered.

Table 6.25. Survey statistics: cross-tabulations for respondent occupation and social risk of criminal acts.

	Architects	Engineers	Quantity Surveyors	Estimators	Project Managers	Construction Managers	All Occupations
1. Modal value for risk likelihood.	Unlikely	Unlikely/ Moderate	Moderate	Unlikely	Unlikely	Rare	Unlikely
2. Range of risk likelihood values encountered.	Rare: Likely	Rare: Almost certain	Rare: Likely	Rare: Almost certain	Rare: Moderate	Rare: Likely	Rare: Almost certain
3. Risk impact type with greatest mean assigned value.	Quality reduction	Injury to people	Injury to people	Injury to people	Time delay	Quality reduction - Injury to people	Injury to people
4. Risk impact type with least mean assigned value.	Environmental harm	Environmental harm	Environmental harm	Cost overrun	Environmental harm	Environmental harm	Environmental harm
5. Preferred risk response type with greatest mean assigned value.	Transfer contractually	Reduce likelihood - Transfer contractually	Reduce likelihood - Transfer contractually	Transfer contractually	Transfer contractually	Reduce likelihood	Reduce likelihood - Transfer contractually
6. Preferred risk response type with least mean assigned value.	Retain	Retain but price in bid	Avoid	Transfer by insurance	Retain/ Retain but price in bid/ Avoid	Retain but price in bid/ Transfer by insurance/ Avoid	Avoid

Key: xx/yy: equal values; xx – yy: second value close to first; xx: yy: range of values encountered.

Table 6.26. Survey statistics: cross-tabulations for respondent occupation and social risk of substance abuse on site.

	Architects	Engineers	Quantity Surveyors	Estimators	Project Managers	Construction Managers	All Occupations
1. Modal value for risk likelihood.	Unlikely	Moderate	Unlikely	Moderate	Moderate	Rare/ Moderate	Moderate
2. Range of risk likelihood values encountered.	Rare: Almost certain	Rare: Almost certain	Rare: Almost certain	Rare: Almost certain	Rare: Almost certain	Rare: Likely	Rare: Almost certain
3. Risk impact type with greatest mean assigned value.	Time delay	Time delay	Time delay	Time delay	Time delay	Time delay	Time delay
4. Risk impact type with least mean assigned value.	Environmental harm/ Injury to people	Environmental harm	Environmental harm	Environmental harm	Environmental harm	Environmental harm	Environmental harm
5. Preferred risk response type with greatest mean assigned value.	Reduce likelihood	Reduce likelihood	Transfer contractually - Retain but price in bid	Reduce likelihood	Transfer contractually	Reduce likelihood	Reduce likelihood
6. Preferred risk response type with least mean assigned value.	Retain/ Retain but price in bid	Retain	Avoid	Avoid	Retain	Transfer by insurance/ Transfer contractually/ Avoid	Avoid

Key: xx/yy: equal values; xx - yy: second value close to first; xx: yy: range of values encountered

Table 6.27. Survey statistics: cross-tabulations for respondent occupation and political risk of industrial relations action.

	Architects	Engineers	Quantity Surveyors	Estimators	Project Managers	Construction Managers	All Occupations
1. Modal value for risk likelihood.	Rare	Rare	Rare	Rare	Rare	Rare	Rare
2. Range of risk likelihood values encountered.	Rare: Unlikely	Rare: Unlikely	Rare: Unlikely	Rare: Unlikely	Rare	Rare: Unlikely	Rare: Unlikely
3. Risk impact type with greatest mean assigned value.	Property damage - time delay	Property damage	Time delay	Injury to people - Time delay	Property damage	Property damage	Time delay
4. Risk impact type with least mean assigned value.	Quality reduction/ Environmental harm	Quality reduction	Quality reduction	Quality reduction	Quality reduction	Quality reduction	Quality reduction
5. Preferred risk response type with greatest mean assigned value.	Retain	Retain	Transfer by insurance	Transfer by insurance	Retain - Transfer by insurance	Transfer by insurance	Transfer by insurance
6. Preferred risk response type with least mean assigned value.	Reduce impact	Retain but price in bid/ Reduce impact/ Reduce likelihood/ Reduce exposure duration/ Avoid	Reduce exposure duration	Reduce likelihood/ Reduce exposure duration	Reduce exposure duration	Reduce impact/ Reduce likelihood	Reduce likelihood

Key: xx/yy: equal values; xx - yy: second value close to first; xx: yy: range of values encountered.

Table 6.28. Survey statistics: cross-tabulations for respondent occupation and natural risk of earthquake.

	Architects	Engineers	Quantity Surveyors	Estimators	Project Managers	Construction Managers	All Occupations
1. Modal value for risk likelihood.	Unlikely	Rare	Rare	Rare	Rare	Rare	Rare
2. Range of risk likelihood values encountered.	Rare: Moderate	Rare: Moderate	Rare: Moderate	Rare: Unlikely	Rare: Unlikely	Rare: Moderate	Rare: Likely
3. Risk impact type with greatest mean assigned value.	Time delay	Time delay	Time delay	Time delay	Time delay	Time delay – Property damage	Time delay
4. Risk impact type with least mean assigned value.	Injury to people	Injury to people	Quality reduction	Quality reduction	Injury to people	Environmental harm	Quality reduction
5. Preferred risk response type with greatest mean assigned value.	Avoid	Retain	Transfer by insurance	Transfer by insurance	Transfer by insurance	Transfer by insurance	Transfer by insurance
6. Preferred risk response type with least mean assigned value.	Reduce impact	Reduce exposure duration/ Avoid	Reduce exposure duration	Reduce likelihood	Reduce likelihood/ Reduce exposure duration	Retain/ Retain but price in bid	Reduce likelihood

Key: xx/yy: equal values; xx – yy: second value close to first; xx: yy: range of values encountered.

Table 6.29. Survey statistics: cross-tabulations for respondent occupation and natural risk of flood.

	Architects	Engineers	Quantity Surveyors	Estimators	Project Managers	Construction Managers	All Occupations
1. Modal value for risk likelihood.	Likely	Moderate	Moderate	Moderate	Moderate	Unlikely/ Moderate/ Likely	Moderate
2. Range of risk likelihood values encountered.	Unlikely: Almost certain	Unlikely: Almost certain	Rare: Almost certain	Unlikely: Likely	Unlikely: Almost certain	Unlikely: Likely	Rare: Almost certain
3. Risk impact type with greatest mean assigned value.	Time delay	Time delay	Time delay	Time delay	Time delay	Time delay	Time delay
4. Risk impact type with least mean assigned value.	Injury to people	Property damage/ Injury to people	Environmental harm/ Injury to people	Environmental harm	Environmental harm/ Property damage/ Injury to people	Injury to people	Injury to people
5. Preferred risk response type with greatest mean assigned value.	Transfer contractually	Transfer contractually	Retain	Reduce likelihood	Transfer contractually	Reduce impact	Reduce likelihood
6. Preferred risk response type with least mean assigned value.	Transfer by insurance	Retain/ Transfer by insurance	Transfer by insurance	Transfer by insurance	Retain/ Transfer by insurance	Transfer by insurance	Transfer by insurance

Key: xx/yy: equal values; xx – yy: second value close to first; xx: yy: range of values encountered.

Table 6.30. Survey statistics: cross-tabulations for respondent occupation and managerial risk of productivity problems.

	Architects	Engineers	Quantity Surveyors	Estimators	Project Managers	Construction Managers	All Occupations
1. Modal value for risk likelihood.	Moderate	Moderate	Moderate	Likely	Moderate	Unlikely/ Moderate/ Likely	Moderate
2. Range of risk likelihood values encountered.	Unlikely/ Almost certain	Unlikely/ Almost certain	Rare/ Almost certain	Rare/ Likely	Unlikely/ Almost certain	Rare/ Likely	Rare/ Almost certain
3. Risk impact type with greatest mean assigned value.	Quality reduction	Quality reduction	Quality reduction	Quality reduction	Quality reduction	Quality reduction	Quality reduction
4. Risk impact type with least mean assigned value.	Environmental harm/ Injury to people	Injury to people	Property damage - Environmental harm	Property damage	Injury to people	Environmental harm/ Property damage/ Injury to people	Property damage
5. Preferred risk response type with greatest mean assigned value.	Transfer contractually	Reduce impact - Transfer contractually	Reduce likelihood	Reduce likelihood	Transfer contractually	Reduce likelihood	Reduce likelihood
6. Preferred risk response type with least mean assigned value.	Retain	Retain/ Transfer by insurance	Avoid	Transfer by insurance	Retain	Transfer by insurance	Transfer by insurance

Key: xx/yy: equal values; xx – yy: second value close to first; xx: yy: range of values encountered.

Table 6.31. Survey statistics: cross-tabulations for respondent occupation and managerial risk of quality assurance problems.

	Architects	Engineers	Quantity Surveyors	Estimators	Project Managers	Construction Managers	All Occupations
1. Modal value for risk likelihood.	Moderate	Unlikely	Moderate	Unlikely	Moderate	Rare/ Unlikely	Moderate
2. Range of risk likelihood values encountered.	Unlikely/ Likely	Rare/ Almost certain	Rare/ Almost certain	Rare/ Likely	Unlikely/ Almost certain	Rare/ Likely	Rare/ Almost certain
3. Risk impact type with greatest mean assigned value.	Time delay	Time delay	Time delay	Time delay - Quality reduction	Time delay	Time delay	Time delay
4. Risk impact type with least mean assigned value.	Injury to people	Injury to people	Environmental harm	Environmental harm/ Property damage/ Injury to people	Property damage	Environmental harm/ Property damage/ Injury to people	Property damage
5. Preferred risk response type with greatest mean assigned value.	Transfer contractually	Transfer contractually	Reduce likelihood	Reduce likelihood	Reduce exposure duration	Retain but price in bid	Reduce likelihood
6. Preferred risk response type with least mean assigned value.	Retain	Transfer by insurance/ Avoid	Avoid	Transfer by insurance	Transfer by insurance	Retain	Avoid

Key: xx/yy: equal values; xx – yy: second value close to first; xx: yy: range of values encountered.

Table 6.32. Survey statistics: cross-tabulations for respondent occupation and managerial risk of human resource management problems.

	Architects	Engineers	Quantity Surveyors	Estimators	Project Managers	Construction Managers	All Occupations
1. Modal value for risk likelihood.	Unlikely	Unlikely	Unlikely	Rare	Unlikely	Unlikely	Unlikely
2. Range of risk likelihood values encountered.	Rare: Likely	Rare: Moderate	Rare: Likely	Rare: Moderate	Rare: Almost certain	Unlikely	Rare: Almost certain
3. Risk impact type with greatest mean assigned value.	Cost overrun	Time delay	Time delay	Time delay - Cost overrun	Time delay	Property damage	Time delay - Cost overrun
4. Risk impact type with least mean assigned value.	Environmental harm	Environmental harm	Environmental harm	Environmental harm	Environmental harm	Environmental harm	Environmental harm
5. Preferred risk response type with greatest mean assigned value.	Avoid	Avoid	Transfer contractually	Avoid - Transfer contractually	Transfer contractually	Avoid	Avoid
6. Preferred risk response type with least mean assigned value.	Retain	Retain/ Retain but price in bid	Reduce exposure duration	Retain	Retain but price in bid	Retain	Reduce exposure duration

Key: xx/yy: equal values; xx - yy: second value close to first; xx: yy: range of values encountered.

Table 6.33. Survey statistics: cross-tabulations for respondent occupation and technical risk of design failures.

	Architects	Engineers	Quantity Surveyors	Estimators	Project Managers	Construction Managers	All Occupations
1. Modal value for risk likelihood.	Unlikely	Unlikely	Unlikely	Unlikely	Moderate	Unlikely	Unlikely
2. Range of risk likelihood values encountered.	Rare: Moderate	Rare: Likely	Rare: Likely	Rare: Moderate	Rare: Almost certain	Unlikely	Rare: Almost certain
3. Risk impact type with greatest mean assigned value.	Time delay	Time delay	Time delay	Time delay	Time delay	Cost overrun	Time delay
4. Risk impact type with least mean assigned value.	Environmental harm	Environmental harm	Environmental harm	Environmental harm	Injury to people	Environmental harm	Environmental harm
5. Preferred risk response type with greatest mean assigned value.	Avoid	Avoid	Transfer contractually	Transfer by insurance	Transfer contractually	Reduce likelihood/ Transfer by insurance	Transfer contractually
6. Preferred risk response type with least mean assigned value.	Retain	Retain but price in bid	Reduce exposure duration	Reduce exposure duration	Retain	Retain	Reduce exposure duration

Key: xx/yy: equal values; xx - yy: second value close to first; xx: yy: range of values encountered.

Table 6.34. Survey statistics: cross-tabulations for respondent occupation and technical risk of equipment or systems failure.

	Architects	Engineers	Quantity Surveyors	Estimators	Project Managers	Construction Managers	All Occupations
1. Modal value for risk likelihood.	Moderate	Unlikely/ Moderate	Moderate	Moderate	Likely	Moderate	Moderate
2. Range of risk likelihood values encountered.	Rare: Almost certain	Rare: Likely	Rare: Almost certain	Rare: Likely	Unlikely: Almost certain	Unlikely: Moderate	Rare: Almost certain
3. Risk impact type with greatest mean assigned value.	Time delay	Time delay	Time delay	Time delay	Time delay	Time delay	Time delay
4. Risk impact type with least mean assigned value.	Property damage/ Injury to people	Injury to people	Injury to people	Injury to people	Property damage	Environmental harm/ Property damage/ Injury to people	Injury to people
5. Preferred risk response type with greatest mean assigned value.	Reduce likelihood	Transfer contractually	Transfer contractually	Transfer contractually	Transfer contractually	Reduce likelihood	Transfer contractually
6. Preferred risk response type with least mean assigned value.	Transfer by insurance	Retain but price in bid	Reduce exposure duration	Transfer by insurance	Retain	Retain/ Transfer by insurance	Transfer by insurance

Key: xx/yy: equal values; xx – yy: second value close to first; xx: yy: range of values encountered.

Table 6.35. Survey statistics: cross-tabulations for respondent occupation and economic risk of materials supply problems.

	Architects	Engineers	Quantity Surveyors	Estimators	Project Managers	Construction Managers	All Occupations
1. Modal value for risk likelihood.	Moderate	Moderate	Unlikely	Moderate	Likely	Unlikely/ Moderate	Moderate
2. Range of risk likelihood values encountered.	Rare: Almost certain	Rare: Likely	Rare: Almost certain	Rare: Likely	Unlikely: Almost certain	Unlikely: Moderate	Rare: Almost certain
3. Risk impact type with greatest mean assigned value.	Time delay	Time delay	Time delay	Time delay	Time delay	Time delay	Time delay
4. Risk impact type with least mean assigned value.	Environmental harm/ Property damage/ Injury to people	Property damage/ Injury to people	Environmental harm	Environmental harm/ Property damage	Environmental harm/ Property damage	Environmental harm/ Property damage/ Injury to people	Environmental harm
5. Preferred risk response type with greatest mean assigned value.	Transfer contractually	Transfer contractually	Retain but price in bid	Retain but price in bid - Transfer contractually	Transfer contractually	Retain but price in bid	Transfer contractually
6. Preferred risk response type with least mean assigned value.	Retain	Transfer by insurance	Avoid	Transfer by insurance	Avoid	Transfer by insurance	Transfer by insurance

Key: xx/yy: equal values; xx – yy: second value close to first; xx: yy: range of values encountered.

Table 6.36. Survey statistics: cross-tabulations for respondent occupation and economic risk of labour supply problems.

	Architects	Engineers	Quantity Surveyors	Estimators	Project Managers	Construction Managers	All Occupations
1. Modal value for risk likelihood.	Unlikely	Unlikely	Unlikely	Moderate	Likely	Unlikely	Unlikely
2. Range of risk likelihood values encountered.	Unlikely: Likely	Rare: Likely	Rare: Likely	Rare: Moderate	Unlikely: Likely	Rare: Likely	Rare: Likely
3. Risk impact type with greatest mean assigned value.	Time delay	Time delay	Time delay	Time delay	Time delay	Time delay	Time delay
4. Risk impact type with least mean assigned value.	Environmental harm	Property damage/ Injury to people	Environmental harm	Environmental harm	Property damage	Environmental harm/ Property damage/ Injury to people	Environmental harm
5. Preferred risk response type with greatest mean assigned value.	Transfer contractually	Transfer contractually	Transfer contractually	Retain but price in bid	Transfer contractually	Retain but price in bid	Transfer contractually
6. Preferred risk response type with least mean assigned value.	Retain but price in bid/ Transfer by insurance	Transfer by insurance	Avoid	Transfer by insurance	Transfer by insurance	Transfer by insurance	Transfer by insurance

Key: xx/yy: equal values; xx – yy: second value close to first; xx: yy: range of values encountered.

Table 6.37. Survey statistics: cross-tabulations for respondent occupation and economic risk of equipment availability problems.

	Architects	Engineers	Quantity Surveyors	Estimators	Project Managers	Construction Managers	All Occupations
1. Modal value for risk likelihood.	Moderate	Unlikely/ Moderate	Moderate	Unlikely/ Likely/ Almost certain	Unlikely	Unlikely	Moderate
2. Range of risk likelihood values encountered.	(Unlikely: Almost certain	Unlikely: Likely	Rare: Almost certain	Rare: Almost certain	Rare: Almost certain	Rare: Almost certain	Rare: Almost certain
3. Risk impact type with greatest mean assigned value.	Cost overrun	Cost overrun	Cost overrun	Cost overrun	Cost overrun	Cost overrun	Cost overrun
4. Risk impact type with least mean assigned value.	Property damage/ Injury to people	Environmental harm/ Property damage/ Injury to people	Environmental harm/ Injury to people	Environmental harm/ Property damage/ Injury to people	Property damage/ Injury to people	Environmental harm/ Property damage/ Injury to people	Property damage
5. Preferred risk response type with greatest mean assigned value.	Reduce impact	Retain but price in bid	Retain but price in bid	Retain but price in bid	Transfer contractually	Retain but price in bid	Retain but price in bid
6. Preferred risk response type with least mean assigned value.	Transfer by insurance	Avoid	Avoid	Transfer by insurance/ Avoid	Transfer by insurance	Avoid	Avoid

Key: xx/yy: equal values; xx - yy: second value close to first; xx: yy: range of values encountered.

Table 6.38. Survey statistics: cross-tabulations for respondent occupation and economic risk of inflation rising.

	Architects	Engineers	Quantity Surveyors	Estimators	Project Managers	Construction Managers	All Occupations
1. Modal value for risk likelihood.	Moderate	Moderate	Unlikely/ Moderate	Likely	Unlikely	Unlikely	Moderate
2. Range of risk likelihood values encountered.	Rare: Almost certain	Unlikely: Almost certain	Rare: Almost certain	Rare: Almost certain	Rare: Almost certain	Unlikely: Likely	Rare: Almost certain
3. Risk impact type with greatest mean assigned value.	Cost overrun	Cost overrun	Cost overrun	Cost overrun	Cost overrun	Cost overrun	Cost overrun
4. Risk impact type with least mean assigned value.	Property damage/ Injury to people	Environmental harm/ Property damage/ Injury to people	Environmental harm	Environmental harm/ Property damage/ Injury to people	Property damage/ Injury to people	Environmental harm/ Property damage/ Injury to people	Property damage
5. Preferred risk response type with greatest mean assigned value.	Retain but price in bid	Retain but price in bid	Retain but price in bid	Retain but price in bid	Retain	Retain but price in bid	Retain but price in bid
6. Preferred risk response type with least mean assigned value.	Retain	Avoid	Transfer by insurance/ Avoid	Transfer by insurance/ Avoid	Transfer by insurance	Avoid	Avoid

Key: xx/yy: equal values; xx – yy: second value close to first; xx, yy: range of values encountered.

Table 6.39. Survey statistics: cross-tabulations for respondent occupation and financial risk of interest rates rising.

	Architects	Engineers	Quantity Surveyors	Estimators	Project Managers	Construction Managers	All Occupations
1. Modal value for risk likelihood.	Moderate/ Almost certain	Unlikely	Unlikely	Unlikely/ Moderate	Moderate	Moderate	Moderate
2. Range of risk likelihood values encountered.	Rare: Almost certain	Rare: Likely	Rare: Almost certain	Rare: Almost certain	Rare: Likely	Rare: Likely	Rare: Almost certain
3. Risk impact type with greatest mean assigned value.	Cost overrun	Cost overrun	Cost overrun	Cost overrun	Cost overrun	Cost overrun	Cost overrun
4. Risk impact type with least mean assigned value.	Injury to people	Injury to people	Environmental harm	Property damage	Injury to people	Environmental harm/ Property damage/ Injury to people	Injury to people
5. Preferred risk response type with greatest mean assigned value.	Reduce likelihood - Retain but price in bid	Retain	Reduce likelihood - Reduce impact	Reduce likelihood	Retain but price in bid	Retain but price in bid	Reduce likelihood
6. Preferred risk response type with least mean assigned value.	Transfer contractually	Transfer by insurance	Avoid	Avoid	Avoid	Retain- Transfer by insurance	Transfer by insurance

Key: xx/yy: equal values; xx – yy: second value close to first; xx: yy: range of values encountered.

Table 6.40. Survey statistics: cross-tabulations for respondent occupation and financial risk of payment delay or default.

	Architects	Engineers	Quantity Surveyors	Estimators	Project Managers	Construction Managers	All Occupations
1. Modal value for risk likelihood.	Unlikely	Unlikely	Moderate	Unlikely	Unlikely/ Moderate	Unlikely	Unlikely
2. Range of risk likelihood values encountered.	Rare: Likely	Rare: Almost certain	Rare: Almost certain	Rare: Almost certain	Unlikely: Likely	Rare: Likely	Rare: Almost certain
3. Risk impact type with greatest mean assigned value.	Time delay	N/a	Cost overrun	Cost overrun	Cost overrun	Cost overrun	Cost overrun
4. Risk impact type with least mean assigned value.	Injury to people	N/a	Environmental harm	Environmental harm/ Property damage/ Injury to people	Environmental harm/ Property damage/ Injury to people	Environmental harm	Environmental harm
5. Preferred risk response type with greatest mean assigned value.	Retain but price in bid - Reduce likelihood/ Transfer contractually	N/a	Retain but price in bid	Reduce likelihood	Transfer contractually	Transfer contractually	Retain but price in bid
6. Preferred risk response type with least mean assigned value.	Avoid	N/a	Reduce exposure duration	Reduce exposure duration/ Transfer by insurance	Retain	Retain	Reduce exposure duration

Key: xx/yy: equal values; xx – yy: second value close to first; xx: yy: range of values encountered.

Table 6.41. Survey statistics: cross-tabulations for respondent occupation and legal risk of adverse contract clauses imposed.

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CHAPTER 7

A CASE-BASED RESEARCH DESIGN

7.1. Introduction.

This chapter includes the justification and development of a case-based research design. The aim of the case studies is to address the research questions in greater depth. As noted in Chapter 1, these questions are:

- (1) Do individual members of project teams have different perceptions of construction risk?*
- (2) How are these perceptions communicated within a project environment?*
- (3) To what extent is risk understanding influenced by stakeholders' prior risk experiences?*
- (4) If different risk perceptions exist, how does this affect the project decision-making?*

Also impacting on these questions are some of the issues identified through the discussion of Chapters 4 and 5, and the findings of the survey research reported in Chapter 6.

The chapter is structured so that, first, the main issues arising from the survey research are clarified. Next, the use of case studies, as an appropriate technique for this research study, is justified. Following this justification, a case-based research design is developed. The case study design first addresses several points of concern affecting the selection of construction projects as case studies, and the conduct of the studies. The design then proceeds to identify the project participants and the nature of the information to be sought. This design is formatted as a tabular instrument, to ensure that adequate data capture is achieved from the semi-structured interviews which will comprise the main information gathering approach to the case studies.

7.2. The survey issues to be explored.

The analysis of the survey data in Chapter 6 produced findings from which a number of issues were identified:

- (a) What is the nature of personal risk experience, and how is it used?
- (b) How are historical records of project risks (risk registers) established and maintained?
- (c) Whose intuition is used and how?
- (d) How is brainstorming used in risk analysis?
- (e) Why is little use made of formal mathematical models and computer simulation techniques?
- (f) If project participants are familiar with risk management theory, and do have some risk management experience, why are they not fully committed to implementing formal risk management systems on their projects?

Other issues identified in the survey related to specific risks from a given catalogue. Where appropriate these are also incorporated into the case study design, but the focus in this investigation will be upon project stakeholders' own risk "stories".

Before proceeding to the case study design, it is appropriate to revert briefly to the literature to consider what other researchers have found with regard to the issues listed above. This will provide the third step in a logical progression - from tentative identification of risk issues; to confirmation of issues; to amplification of confirmed issues; and thence to deeper exploration of issues in a project context.

7.2.1. The nature and use of personal risk experience

The literature describes personal experience as a source of potential bias in risk assessment (Birmie, 1993; Mak, 1992). However, the survey (Chapter 6, Tables 6.5. and 6.6.) confirms the findings of other researchers (e.g. Potts and Weston, 1996; Akintoye and MacLeod, 1997; Bajaj *et al.*, 1997; and Jackson *et al.*, 1997) which have shown that construction industry professionals prefer personal experience above all other methods for at least the initial identification and analysis of risks. What the survey, and the literature, do not elaborate is the nature of this experience and how it is used in risk management. What are project stakeholders' risk experiences on construction projects? How did they arise? What were the project outcomes? How have they affected the individual's perceptions of, and attitudes towards, risk on current projects? How does the communication of risk perception occur? These are the sorts of questions to be directed at case study participants, so that a "richer" picture of construction risk management can be obtained.

7.2.2. Historical records of project risks

The questionnaire survey (Chapter 6, Tables 6.5. and 6.6.) revealed that the findings of Potts and Weston (1996), with respect to the use of historical project risk records, were optimistic. Few construction professionals appear to formally document the risk events of previous projects, despite the apparent value of such a resource for risk management on future projects. This contrasts with quantity surveying consultants' preference for in-house cost data (Bowen, 1993). The case studies will help to determine the level and type of risk documentation that does occur, and why it is not carried out more extensively.

7.2.3. Risk intuition

Several researchers (e.g. Potts and Weston, 1996; Akintoye and MacLeod, 1997; Bajaj *et al.*, 1997; and Jackson *et al.*, 1997) have noted how construction professionals responding to their surveys placed a heavy emphasis upon personal intuition as an analytical tool in risk management. These findings are confirmed by this survey research (Chapter 6, Tables 6.5. and 6.6.). An intuitive approach to risk analysis also seems to go hand in hand with risk experience. Exactly how experience and intuition work together, and how the latter is used, are not understood. While such knowledge might be derived synthetically, through psychological experiment, it should be possible to gather at least some understanding through the personal "stories" of participants in the case studies.

7.2.4. Brainstorming in risk analysis

Potts and Weston (1996) found that brainstorming was a popular approach to risk analysis, and this has been confirmed by the survey research (Chapter 6, Tables 6.5. and 6.6.) where this technique was second only in popularity to intuition among construction professionals. But how is brainstorming used, and how effective is it? Who participates? What is the brainstorming environment? Case studies should reveal a better picture of this phenomenon and how it is used for risk management on construction projects.

7.2.5. Formal risk analysis models

With the exception of Simister (1994), whose data were not exclusively related to the construction industry, the extant surveys, and this survey research, have found that formal, mathematically-based risk analysis techniques are poorly supported in construction project risk management. Lack of experience, application time requirements, cost, and inadequate data have all been given as reasons for failure to make greater use of such techniques.

While the case studies will probably confirm this *status quo*, they should provide an opportunity to explore with project stakeholders the circumstances in which this situation might be changed.

7.2.6. Risk management systems

This survey research found that fewer than 25% of construction professionals responding to the survey had actually implemented some formal type of project risk management system in their organisations (Chapter 6, Table 6.5.). This finding compares with the 40% found by Potts and Weston (1996); the 9% found by Pasquire (1996), and the 30% found by Amos and Dent (1997). These findings appear to parallel those concerning respondents' knowledge and understanding of risk theory. It is important, therefore, to investigate why this is so, given the increasing attention being given to project risks, the expectations of clients, and the growing availability of national standards and guidelines for risk management. The case studies should be capable of shedding light on this. If risk management systems are found among the case studies, information on their operation and performance can be gathered.

7.3. Justification of a case study approach.

Thus far, this research has explored theoretical understandings of risk and risk management (Chapter 2) and their general application to construction projects (Chapter 3). This has been followed by a discursive treatment of the decision-making context of projects within which risk management must take place (Chapter 4). The results of a survey of the risk perceptions and risk management practices of construction professionals have been presented (Chapters 5 and 6). The next step is to carry out a more microscopic *intra-project* investigation of the major issues arising from earlier parts of the study, in order to gain a richer picture of project risk dynamics and transactions through the eyes of the key project stakeholders – the players in the temporary multi-structure organisations of projects (Chapter 4). This investigation is best suited to case study research.

A case-based approach to this aspect of the research may be justified on the grounds of contemporaneity, the researcher's role, the research purpose, and also in terms of data validity.

According to Yin (1994), case studies, compared to other research strategies such as experiments or surveys, provide the opportunity to focus on contemporary events, particularly for organisational and management studies in “real life” situations. Further, they do not require the researcher to have any control over behavioural situations, leaving the investigator free to act as observer, i.e., the researcher has a passive, rather than active, role and is freed of the danger of imposing his or her influence on the case. Case studies are also suited to the “how” and “why” types of research questions where the purpose is to seek explanations.

As a largely qualitative form of research, case studies may be vulnerable to criticism in terms of their data validity and the reliability of the data collection procedures.

Construct validity in this research is achieved by using multiple sources of evidence (e.g., the extant literature and the survey research, plus the case studies) to gather convergent lines of evidence in a logical chain sequence. Thus the necessary triangulation of evidence and its *verstehen* (credible understanding) is achievable (Strauss, 1987).

Internal validity is achieved through the extent to which inferences drawn from the data collected from one of the actors in the case study are supported by the observations of other actors in the project. Bryman (1988) notes that internal validity also has to do with the fit between the concepts (issues) involved and their measures. Internal validity is also assisted by ensuring that interview transcript summaries are subsequently checked for factual accuracy by the interviewees.

External validity (the capacity to generalise findings beyond the context of the case itself) is more difficult to achieve in case study research. Certainly it may be conclusive in terms of contradicting or falsifying theory (Chapter 5), but it is necessarily less so in terms of supporting or confirming theory. Case studies are limited in their capacity to be representative of whole populations. Here, however, the uniqueness and heterogeneity of construction projects is an advantage. If several case study projects can be explored in a consistent and repeatable operational manner then, given the closeness of any findings, it may be possible to make some reliable generalisations about all projects. Alternatively, the findings may constitute *grounded theory* (Strauss, 1987) by contributing to new (or an extension of existing) theory.

Thus the reliability of the research is sought from triangulation of the construct validity, the internal validity and the external validity. This requires a research design for the case studies in the form of an operational protocol (Yin, 1994).

7.4. A case study design.

This section describes a protocol design for the collection of data from the case studies. It discusses aspects of the case units, the preferred analytical strategy, the case selection, and the nature of the information to be sought.

7.4.1. Units of analysis

Given the appropriateness of a case study approach to the research, it is essential to decide upon the unit(s) of analysis (Yin, 1994). For this research, the construction project comprises one unit of analysis. It is within the project context that decision-making, and hence risk management, occurs.

Equally important as units of analysis will be the project stakeholders and their organisational environments.

7.4.2. Analytical strategy

According to Yin (1994), strategies available for the analysis of case studies may include:

- Illustration
- Agreement/difference
- Domain analysis
- Ideal types
- Content analysis
- Pattern matching
- Explanation building
- Time series

For this research, illustration and ideal types analyses are inappropriate, as it is not intended to typify cases against a given norm. Nor will domain analysis be useful, given that project heterogeneity is sought for the cases. Time series analysis is not likely to be required, as the data are not temporally linked on an inter-project basis.

The analytical strategies required are most likely to include simple content analysis of the stakeholders' answers to interview questions, and pattern matching of this data. This will facilitate comparisons (agreement/difference) on an *intra-* and *inter-* project basis, which should permit subsequent explanation building.

7.4.3. Concerns of case selection

Several points of concern must be addressed before the case studies can be selected. Important among these are:

- Project heterogeneity versus homogeneity
- Project location
- Stakeholder spread
- Project currency
- Project access
- Study approach

Project heterogeneity versus homogeneity

The concern here is whether the case study projects should be homogenous in nature; ie. of similar type and scope, or whether a heterogeneous project approach should be adopted. The argument for homogeneity is that more controlled comparisons might be possible, ie. office building projects would be compared with office building projects. A counter argument asks not only whether such comparisons would be valid, but also if they are necessary and desirable.

Justifying a homogenous approach to case project type would actually require *a priori* deductive argument with an appropriate hypothesis. For example, the adoption of a particular case project type might be required by a hypothesis which postulated that "...office buildings are prone to risks type *x* because of the presence of factors *y* and *z*." To test such an hypothesis, would require not only a representative sample of office building projects, but a sample also representative in terms of similarities of other factors such as scope, method of construction, location, procurement method, construction market conditions – in other words, projects of similar complexity (cf. discussion of complexity in Chapter 4). The uniqueness attaching to every construction project would be a confounding variable which might prove difficult to control. In the research described here, the disadvantages of homogeneity were thought to outweigh the advantages.

- The research explores risk management practices in a project environment, and in the purest sense is not concerned with practices on particular *types* of projects. If it were, then a large number of cases would be required to establish validity for the findings. The difficulty of doing this for homogenous projects might well be insurmountable, and even if it were possible the applicability of the findings would be constrained. This part of the research is actually seeking data "richness" in terms of the personal stories and practices of participants, and will then attempt to draw

meaning from them through inductive reasoning. To that end it is not concerned with homogenous project comparisons.

While the decision to select heterogeneous case projects does not then permit any substantive findings to be claimed in relation to project homogeneity, it does not preclude them from being flagged for future, more typologically-based research.

For these reasons, project heterogeneity is preferred. No attempt is made to limit the nature and scope of the case studies to any pre-determined characteristics of building function or construction method. This allows a measure of randomness to occur in case selection, in that individual building professionals can be approached in their professional capacities and asked to nominate suitable projects for study.

Project location

While the randomness referred to above is desirable, it is constrained by the exigencies of the researcher's ability to investigate the projects. For practical logistic reasons, it has been possible to locate cases in Singapore and in the Western Cape province of South Africa. No particular significance attaches to these location variables, other than the possibility of identifying cultural influences on risk management practices. It was noted in Chapter 5 that building procurement systems in different countries are undergoing different processes of change, and this too may impact upon the management of risk.

Stakeholder spread

The complexities of stakeholder spread were discussed in Chapter 4. To attempt to include every stakeholder in each case study would be impractical from a research point of view. In any event it is not part of the objectives of this research, which focuses on the risk management practices of key project participants. These participants (stakeholders) were identified in Chapter 4 as including the client, project manager, professional consultants such as architect, engineer and quantity surveyor, main contractor and specialist sub-contractors. The case study interviews are therefore generally targeted at these participants, and any exceptions are noted in the analyses.

Project currency

In choosing between historical (ie. completed) and current projects as case studies, Amtoft's (1994) advice about the "freshness" of stories has been observed, and current "live" projects are targeted for the case-based investigations. The currency is aimed at the design and pre-construction phases (either or both) of projects, rather than at the construction and operational

phases, as it is in the design and pre-construction phases where the *loci* of risk management are mostly determined. Similarly, since this part of the research is intended to explore what risk management practices actually occur during these early phases, and not how effective they have been (or might have been) in hindsight, it is not necessary to use completed projects as case studies. In this instance, freshness is preferable to historicity.

Project access

Access to suitable case study projects will be initiated through personal contacts in the construction industries of Singapore and South Africa. The initial contacts will be asked to nominate the case study projects, and provide introductory access to the clients, so that the necessary permissions can be obtained to approach other project stakeholders.

Study approach

Given the decision to target live projects, a concomitant issue becomes that of the type of approach for the researcher to pursue. Alternatives include simulation of different risk strategies or techniques; direct interventions by the researcher; and live impartial observation of project transactions (e.g. Loosemore, 1993).

As the research does not incorporate the testing of new techniques or strategies of risk management, the first approach is inappropriate. Nor is the second, as it is not the intention of the researcher to attempt to change the risk behaviours of particular participants on particular projects.

While the live observation of risk management practices would be valuable in terms of the support it would lend to data validity, it is also impractical as risk decisions and transactions are unlikely to occur in a formal, pooled environment (such as a design team meeting, for example) but are more likely to be undertaken *ad hoc* and individually by project participants (see discussion in Chapter 4). This militates against deliberately planned live observation. However, should opportunities arise to observe risk decision-making at first hand, they will be grasped.

The anticipated study approach will be that of impartial recording of project participant's risk "stories" through personal interviews, using a structured but flexible question framework to elicit information. The flexibility is important in terms of the data "richness" sought, while structure is essential to ensure that participants' perceptions of important risk management issues are not overlooked.

7.4.4. Case selection

Following upon the project access method referred to above, case study projects are selected on the basis of project currency, and availability of participants and their willingness to be interviewed. Selection thus incorporates a degree of "accidental" randomness, particularly as the initial access contacts are not stratified by professional discipline.

Little guidance exists as to the number of cases required. Yin (1984) suggests that more than one is necessary, in order to provide adequate triangulation in terms of data validity. Informal consultation with social scientists brought forth opinions of minimum numbers varying from two to twelve. Perhaps the most valuable advice offered was that the number should be sufficient not only to triangulate the data, but also to "saturate" the issues to be explored. The latter was accepted as a guiding principle and in the event three case studies were used.

7.4.5. Case descriptive data requirements

In order to provide contextual background to the subsequent data analysis and discussion, some descriptive characteristics of the cases and their environments must be captured. Table 7.1 lists the required information in point form. Much of it should be obtainable from one or more of the project stakeholders, and verifiable in the same way. Project documentation and secondary information sources (national and industry statistics) can be used to supply the rest.

The contextual background of the construction projects is important for helping to assess whether or not an adequate level of risk management is present in the case studies. This in turn is determined by the level of project risk which exists. Despite their emphasis on risk analysis, Cooper and Chapman (1987) provide a useful summary of the rationale for formal risk management, suggesting that it is essential for informed decision-making on projects involving large capital outlays, unbalanced cash flows, new technology, unusual contractual arrangements, important political concerns, sensitive environmental issues, or stringent regulatory requirements.

Similarly, Smith (1999) poses a series of questions which should be addressed in order to establish the "riskiness" of projects:

- 1. Is the client's business or economy sensitive to the outcome of the project in terms of the performance and quality of its product, capital cost and timely completion?*
- 2. Does the project require new technology or the development of existing technology?*

3. *Does the project require novel methods?*
4. *Is the project large and/or extremely complex?*
5. *Is there an extreme time constraint?*
6. *Are the parties involved sufficiently experienced?*
7. *Is the project subject to regulatory changes?*
8. *Is the project in a developing country?*

The inference here is that “yes” answers to Questions 1 to 5, and 7 and 8, and a “no” answer to Question 6, will indicate a “risky” project (which Smith (1999) then suggests should not proceed). By extension, “no” answers to any of Questions 1 to 5, 7 and 8 would indicate a relatively less risky project. A “yes” for Question 6, although not determining the riskiness of the project, suggests that a higher level of risk could be accepted in such circumstances.

Based upon this approach, a qualitative view of the relative riskiness of the case study projects should be possible, together with an assessment of their levels of risk management.

<u>Case studies: project descriptive requirements</u>
Type, scope and location of project
Type of client
Project objectives
Procurement system for project
Organisational structure of project
Predominant structural design system
Predominant construction method
Contract period and phasing
Contract value
Cash flow graphs if available
Organisational structures of relevant project stakeholders
Prevailing economic and financial indicators
Prevailing construction industry indicators
Relevant political, regulatory, sociological and environmental factors
Special contract clauses

Table 7.1. Case protocol design: descriptive requirements.

7.4.6. Case interview data requirements

Within the case studies, the majority of the required data will be collected through semi-structured face-to-face interviews with the key project participants. The nature of the questions to be asked is set out in Table 7.2. Each question is rationalised in terms of the research questions and issues noted in earlier chapters. As the questions are largely generic in terms of projects and stakeholders, they will be addressed to all participants.

This design protocol is structured in the sense that it will be used to guide the nature of the material to be discussed in the project case study interviews, thus preventing any unwanted distraction from the main purpose. Care will be necessary to maintain a balance between over-rigid adherence to the protocol by the interviewer and licence to ramble on the part of the interviewee. Nevertheless, flexibility in the interview process is likely to be a key factor in successfully capturing participants' risk stories.

As a prompt to project case study participants, a catalogue of risks, as shown in Table 7.3 will be made available for use in the interviews. This catalogue is derived from the risk categorisation material devised as part of Chapter 2. However, participants will be encouraged to identify and expand upon their own project risk experiences as much as possible.

Question	Rationale
Is the client's business or economy sensitive to the outcome of the project in terms of the performance and quality of its product, capital cost and timely completion?	Testing participants' perception of the "riskiness" of the project, and identifying potential risk "triggers".
Describe any new technology or major development of existing technology or new procurement methods required on this project.	Testing participants' perception of the "riskiness" of the project, and identifying potential risk "triggers".
Describe the project in terms of its size and complexity.	Testing participants' perception of the "riskiness" of the project, and identifying potential risk "triggers".
How severe are the completion deadlines for the project?	Testing participants' perception of the "riskiness" of the project, and identifying potential risk "triggers".
Describe any regulatory changes which you think could impact on the project.	Testing participants' perception of the "riskiness" of the project, and identifying potential risk "triggers".
How would you describe the level of project experience of each of the other stakeholders in this project?	Testing participants' perception of the "riskiness" of the project, and identifying potential risk "triggers".
Describe the objectives of this project.	Exploring the risk context of the project.
Describe any of your organisational activities or operations which YOU specifically subject to risk management processes on this project.	Identifying the major "loci" of risk management for each participant.
Describe how you personally go about the processes of risk management.	To ascertain the level of formal risk management employed.
To what extent does your <u>organisational</u> risk management approach conform to a standard approach established by your company?	To compare actual risk management procedures with company policies.
To what extent does your organisation: (a) establish criteria for measuring the success or failure of your risk decisions? (b) record its risk decisions and the decision process? (c) conduct post-project risk decision analysis?	To explore risk decision-making effectiveness and risk monitoring.
How would you wish to improve your personal/organisational risk decision-making?	To explore decision learning.
How would you describe the <u>project</u> risk management process on this project - systematic or ad hoc?	To compare actual risk management processes with standard guidelines (literature).
What prevents the project risk management process from being more systematic?	To explore why risk management systems are not used more extensively.
Describe any education and/or training you have had in risk management.	To establish levels of risk management knowledge.
Describe how you would go about IDENTIFYING YOUR organisation's risks on this project, and the sequence of information gathering.	To establish participants' risk identification processes and the effect of information order.
Describe any risk register system maintained by your organisation.	To explore the use of historical project risk records.
Describe how you would go about ANALYSING/ASSESSING <u>three</u> identified PROJECT risks on this project?	To establish participants' risk analysis processes.
Describe any computerised risk analysis processes to be used on this project.	To check the usage of formal computer/mathematical risk assessment models.
Explain why formal computer/mathematical risk assessment models are not used/not used more extensively on this project.	Reasons for non-usage sought.

Table 7.2. Case study interview design protocol.

Will you/did you get together with others to "brainstorm" the risks on this project? Why/ Why not? When? Where? With whom? How?	To explore risk brainstorming (and to identify any "groupthink" symptoms).
Using the catalogue (Table 7.3.) identify any risks you have actually experienced on previous projects.	To explore participants' personal experiences and learning.
Describe the circumstances of these risk events (occurrence/impact/response)	To explore participants' personal experiences and learning.
Describe any risk events not listed in the catalogue.	To explore participants' personal experiences and learning.
Explain, using examples, situations where you think you have an intuitive feeling for risks on this project.	To explore the use of personal intuition.
How would you describe your <u>professional</u> risk profile (risk seeker, risk neutral, risk averse)?	Risk profile exploration.
How would you describe your <u>personal</u> risk profile (risk seeker, risk neutral, risk averse)?	Risk profile consistency exploration.
How would you describe the <u>professional</u> risk profile of other project stakeholders (risk seeker, risk neutral, risk averse)?	Capability of assessing profiles.
How would you describe the <u>personal</u> risk profile of other project stakeholders (risk seeker, risk neutral, risk averse)?	Capability of assessing profiles.
How are risk issues communicated? (intra-company, intra-project)?	To explore risk communication.
Describe any media used for feedback or monitoring of risk management processes.	To explore risk communication.

Table 7.2. Case study interview design protocol (Contd.).

<u>Risk Type</u>	<u>Risk Category</u>	<u>Risk</u>
Natural	Weather systems	Flooding occurs
		Lightning strikes
		Hurricane occurs
		Tornado occurs
		Typhoon occurs
		Tidal wave occurs
	Geological systems	Earthquake occurs
		Volcanic eruption occurs
		Geotechnical fault/anomaly is encountered
Human	Social risks	Criminal acts occur on site (e.g. vandalism, theft)
		Civil torts occur (e.g. trespass, bill posting)
		Substance abuse occurs on site (e.g. drugs, alcohol)
	Political risks	War breaks out
		Civil disorder occurs (e.g. riot)
		Industrial relations action occurs (strike, lockout)
		Protest lobby action occurs (e.g. "green" protest)

Table 7.3. Construction project risk catalogue.

Human	Economic risks	Materials supply shortages occur
		Labour supply shortages occur
		Equipment availability problems encountered
		Exchange rates deteriorate
		Inflation exceeds forecasts
		Import tariffs/quotas imposed or worsen
		Fiscal policies change adversely
	Financial risks	Interest rates exceed forecasts
		Credit ratings deteriorate
		Capital supply deteriorates
		Overdraft facilities withdrawn
		Project incomes less than forecast
	Legal risks	Adverse contract clauses imposed
		Harsher codes/regulations imposed
	Health risks	Epidemia occur on site (e.g. hepatitis)
	Cultural risks	Adverse religious incidents occur
		Adverse cultural incidents occur
	Managerial risks	Productivity worse than planned
		Quality assurance failures occur
		Inadequate cost control systems applied
	Managerial risks	Human resource management problems occur
		OH & S systems inadequate
	Technical risks	Design failures occur
		Construction equipment/systems failures occur
		Estimation errors occur
		Collisions or accidents occur
	Other?	??

Table 7.3. Construction project risk catalogue (Contd.).

7.5. Conclusions.

This Chapter has provided a justification for using a case-based approach for investigating, at a deeper level, the research questions of Chapter 1 and the issues identified from the literature reviews of Chapters 2, 3 and 4, together with those from the survey research of Chapters 5 and 6. The main units of case analysis will be the construction project, together with the project stakeholders and their organisational environments. In order to explore this material, an intra-project case study protocol has been designed for capturing descriptive project and the data derived from semi-structured interviews with the main project stakeholders. The strategy of case analysis will comprise simple content analysis, pattern matching and explanation building, with inter-project comparisons. The case study data are presented and interpreted in Chapter 8.

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CHAPTER 8

CASE STUDY ANALYSIS

8.1. Introduction

This chapter presents the analysis of the primary data collected through the case study projects, together with an interpretation of the data and a discussion of the findings.

As noted in Chapter 7, the individual projects and their project stakeholders form the main units of analysis, in the context of their organisational environments. The analytical strategies employed include simple content analysis of the stakeholders' answers to interview questions, and pattern matching of the data on an *intra-* and *inter-* project basis.

The case studies comprise one project in Singapore, and two projects in the Western Cape province of South Africa. After preliminary analysis of the first two cases, it was considered that three would be sufficient to "saturate" the issues to be explored (Chapter 7).

Each case study commences with a description of the project and an illustration of its organisational structure, followed by summaries of the interview responses of project stakeholders, together with their individual organisational structures. The intra-project analysis tabulates the case study participants' responses in order to explore the "riskiness" of each project, using the criteria established by Smith (1999) and as set out in Chapter 7. Stakeholder responses are also used to make an assessment of the nature and extent of risk management practiced on each project. The processed data are then used for inter-project comparison and discussion. The chapter concludes with a summary of the research findings from the case study investigation.

8.2. Case S1

8.2.1. Project description

The Singapore case study is a new factory building project located at the rear of existing factory premises in Tuas (Jurong), Singapore. At the time of data collection, the contract had been signed between the client and main contractor.

The organisational structure for the factory project is shown in Fig. 8.1. In terms of the Mintzberg (1979) and Parkin (1996) typologies noted in Chapter 4, it can be described as a temporary, administratively-ordered, simply-structured professional bureaucracy .

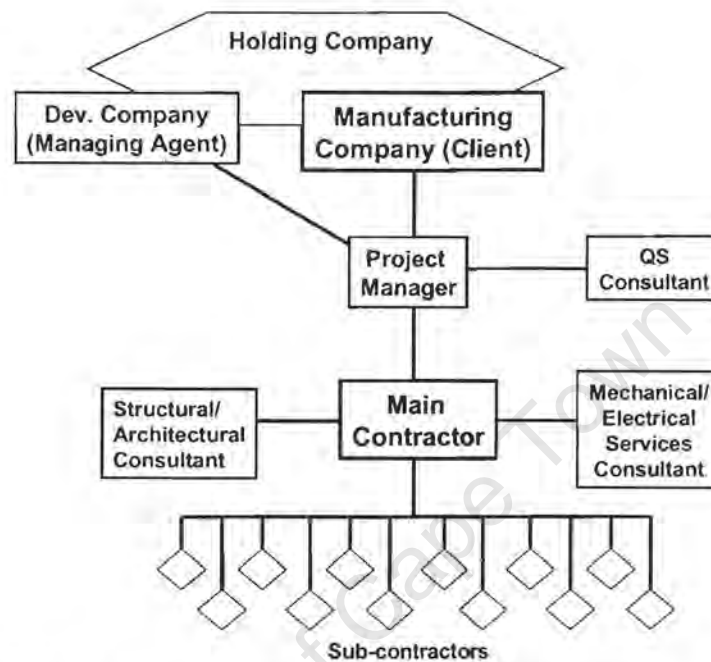


Fig. 8.1. Case S1: Project organisational structure.

The client is a subsidiary manufacturing company of a diversified international holding company, which has specialised technology interests. Another wholly-owned subsidiary is engaged as the project agent to act on behalf of the client company. Property development is not a core activity in Singapore for the agent company, although through another subsidiary of the holding company it has been involved in several construction projects in China.

The project manager is employed by the subsidiary agent company. The procurement system for the project is design-build. Tenders were invited from a selected list (provided by the quantity surveyor) of five contractors, chosen for their knowledge and experience with this type and size of project. The successful tenderer was awarded the contract on the basis of his bid price and design proposals.

The project organisational structure comprises the manufacturing subsidiary as client, with the project manager as client's representative. A local firm (part of an international conglomerate) has been appointed by the client to provide quantity surveying services on the project.

The main contractor has appointed structural, and mechanical and electrical, engineering design consultants, respectively. The structural engineering consultant's role also includes the architectural design for the factory. The contractor is responsible for the design consultants' work, obtaining all necessary permits, and for the construction work, including all sub-contractors.

The building comprises three storeys, with a gross floor area of 2800 m². The plan shape is approximately rectangular. Bored piling is used for the foundations, and the structure is a reinforced concrete frame with reinforced concrete floor and roof slabs. Construction methods are generally conventional, with brick walls, simple finishes and services commensurate with this type of building in Singapore. No innovative technology will be required for the construction of the factory, although the client's brief specifies that the ground floor space should be free of internal columns. This entails using larger perimeter columns with three deep transverse post-tensioned concrete beams to the first floor slab. The ground floor has a clear height of 4.7m to allow for fork-lift operation inside. The upper two floors are conventional two-way beam and slab construction and incorporate internal columns. The air treatment design is intended to meet general clean air, as distinct from ultra-clean air, manufacturing environment standards.

The contract period is 44 weeks (June 2000 - April 2001) and the project is to be completed in a single phase. A contractor's activity program was a required submission under the conditions of contract. The program shows a 15-week pre-construction design period, incorporating a three-week mobilisation period. This is followed by a two-week period for piling, and fourteen weeks for the completion of the reinforced concrete frame and roof slab. The contract value of the project is S\$2.6 million (ZAR10.3 million), which includes all fees. No abnormalities were detected in the cash flow forecast for the project (supplied by the quantity surveyor). This document is intended to form the basis for monthly progress payments to the contractor and his consultants.

Special clauses in the contract are intended to protect the operational efficiency of the client's existing factory on the site, and the ability of the new building to meet the client's needs. These clauses:

- require the completed building to fit for its purpose;
- do not permit any construction workers to live on the site; and
- require the contractor to minimise noise, disturbance and waste pollution during construction activities.

In terms of the third point, bored piling was chosen for the foundation design, rather than the more usual (and cheaper) precast driven piling. When the test bored pile casing was extracted, the client was present on site in order to observe the vibration effect and noise, as this part of the piling operation was considered to present the most risk to the operating environment of the existing factory.

The client's business (manufacturing electrical components) is most sensitive to timely completion of the project, as the project objective is to acquire additional manufacturing space for the production of components to supply a currently expanding international market. Failure to complete the project on time will endanger the company's market opportunity, and the penalty clauses in the contract reflect this.

On the factory project, face-to-face interviews were carried out in Singapore during July-August 2000, with the project manager, quantity surveyors, main contractor and structural engineering consultant.

8.2.2. Interview summaries

Project Manager

The project manager (S1PM) for the new factory building is employed by the development company appointed as managing agents for the project. He was interviewed in his city office in Singapore. The interview lasted just over one hour.

S1PM holds a B.Sc. (Econ.) Mgmt. Hons. Degree from the University of London, and has previous successful project experience on approximately five completed projects, of differing types, with the parent holding company. S1PM has had no formal education or training in risk management, other than the "school of hard knocks".

In terms of risk profile, S1PM considers himself to be relatively risk averse in his professional capacity. In his private life he thinks he is risk averse in personal finance and career matters, but a risk seeker in his sport and leisure interests. He believes that the other participants in the factory project are all professionally risk averse, but has no knowledge of their personal risk attitudes.

S1PM reports directly to the two directors of the client manufacturing company. He has not worked previously with the main contractor for the factory project, but knows the main contractor

by reputation as another division of the parent holding company has previously used them as contractors.

S1PM considers the new factory building to be a small, relatively uncomplicated project. The spatial requirements are clear, but there are some issues of configurational complexity in terms of installing services (electrical outlets, etc.) to provide operational flexibility for the client's production machinery.

In S1PM's opinion, the completion deadlines for the project are severe, and the contract agreement contains a liquidated damages clause for late completion. He notes that establishing the amounts was difficult in terms of avoiding the risk of tenderers pricing for the penalties in their tenders on the one hand, and of discouraging tenderers from bidding altogether, on the other. No completion bonus clauses were used.

No regulatory changes were anticipated which could impact on the project.

S1PM has no factual evidence of the level of experience of the other project participants. He considers the quantity surveying consultants to be experienced. He believes that the main contractor is a relatively young company (approximately 5 years old), but their construction manager for the project has considerable experience. S1PM has no knowledge of the experience of the contractor's design consultants, since this a design-build project.

S1PM believes that time management is the major risk factor on the project. To deal with this, a global program was sought from the contractor during the negotiation stage. After the contract was awarded, the contractor was required to submit a detailed construction program, and S1PM requested detailed clarification from the contractor on several points.

Neither the parent holding company, nor either of its two subsidiary companies involved in this project, uses a formal processes of project risk management, and therefore they do not have a standardised approach to risk management. A formal systematic approach is considered unnecessary and un-economic where the project is a small one like the factory. No risk register is built up from previous projects and maintained. Each project is examined on its merits to identify factors critical to the success of the project. These factors are identified (through the client's brief) at the inception of each project and, for management decision-making, emphasis is concentrated on controlling and monitoring them.

On the factory project, the three traditional project objectives of time, cost and quality were identified as being the major critical factors (sources of risk) to the client. Decision-making relating to these areas is formally recorded in writing, both within S1PM's organisation and within the project organisation. No computerised risk analysis processes were used to explore the risks associated with these objectives, as it was felt that sophisticated techniques were not necessary. These risks have been dealt with by passing them on contractually to the contractor through the design-build procurement system. The time aspect is monitored by S1PM as noted above. Cost is monitored by the consulting quantity surveyor, who advises the client through S1PM. The quality objective/risk is monitored and controlled through the project specification.

For the factory project, client change requests are formally recorded in writing, but not any construction changes informally communicated by the contractor as these are his responsibility under the design-build contract.

No formal post-contract analysis of project decision-making is conducted. Nor is any de-briefing of stakeholders carried out.

For S1PM, faster decisions from the client, and fewer changes to projects, would improve the decision-making process and thus reduce his risks.

Quantity Surveyor

The quantity surveying consultants for the factory project were interviewed at their city offices in Singapore. The interview lasted approximately one and three quarter hours.

The company is a large local autonomous firm (200+ employees) with links to an international conglomerate. The organisational structure for the quantity surveying consultants is shown in Fig. 8.2 and can be described as an administratively-ordered divisionalised professional bureaucracy.

On this project, the quantity surveyors were appointed by the client manufacturing company to provide them with procurement advice, and cost planning and contract administration services. No bills of quantities were prepared.

The interviewees included the responsible director for the project (S1QS1) and his project team leader (S1QS2).

S1QS1 is an associate director of the company and has responsibility for three project teams within his organisation. Associate directors with project team responsibility report to one of two managing directors of the company, who in turn report to the company chairman.

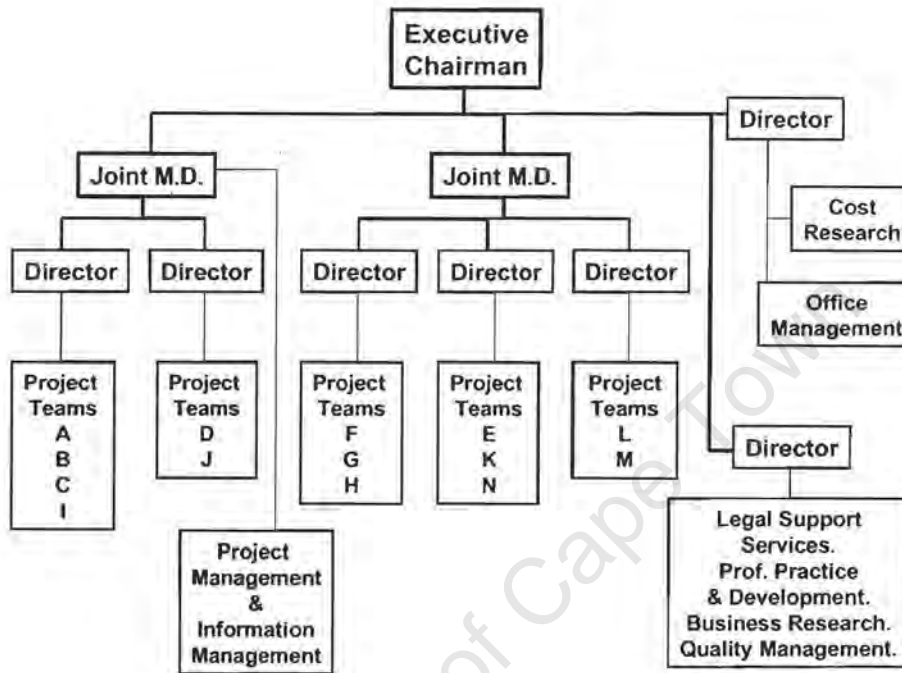


Fig. 8.2. Case S1: Organisational structure for quantity surveying consultant.

S1QS1 holds a B.Sc.Q.S. degree and has 17 years experience as a professional quantity surveyor. He is a registered quantity surveyor with the Board of Surveyors, Malaysia. S1QS2 has a diploma qualification and holds a Bachelor of Technology degree from the University of South Australia. She has 14 years of professional experience. Neither of the interviewees has had formal education or training in risk management, other than through on-the-job experience.

S1QS1 and S1QS2 consider the new factory building to be a small, relatively uncomplicated project. No regulatory changes were anticipated which could impact on the project.

The completion deadlines for the project are considered to be severe, and the contract agreement contains a liquidated damages penalty clause for late completion. No completion bonus clauses were used, as S1QS1 suggests that there is little opportunity for speeding up construction operations in terms of the construction program submitted by the contractor.

S1QS1 and S1QS2 believe that time management, cost and quality are the major risk factors on the project. These are dealt with through the design-build procurement system, their appointment as quantity surveyors, and the agreed specification, respectively.

The quantity surveying company has not worked previously with the other project participants. The client company's managing director is considered to be substantially experienced in the building requirements for manufacturing premises, and his assistant is acquiring similar experience under his direction.

S1QS1 believes that the project manager is appropriately qualified, and has adequate experience, to fulfil his duties as project manager.

Neither of the interviewees has any factual evidence of the level of experience of the other project participants. They are satisfied with the experience of the main contractor's managing director, and S1QS1 made enquiries through other architects to satisfy himself about the reputation and experience of the construction company itself.

S1QS1 is satisfied with the professional competence of the engineering, architectural and services design consultants appointed by the main contractor.

In terms of risk profile, S1QS1 and S1QS2 each consider themselves to be risk averse in their professional capacities. In his private life S1QS1 believes he is a moderate risk seeker in pastimes such as minor gambling but risk averse in personal finance and sport. S1QS2 considers herself risk averse in all matters relating to her family and personal life.

The quantity surveying company does not use formal, explicit processes of project risk management within the organisation, and does not offer this service to clients on the grounds that such a label might unnecessarily alarm clients.

However, the company practices substantial levels of implicit risk management through its quality assurance procedures. In addition to the objective of providing quality assured services to clients, the procedures also have the aim of minimising the potential occurrence of events that might lead to claims of professional negligence against the company. This approach ensures that the cost of professional indemnity insurance is contained to an acceptable minimum level.

The company therefore does not have a standardised approach to risk management *per se*, but its operational processes are subject to the requirements of the ISO 9000 - certified quality assurance system adopted by the company. It was the first quantity surveying company in Singapore to achieve this certification.

For its cost planning, contract documentation and contract administration services, the company's implicit risk management includes authorised levels of signing powers, bulk checks on documents containing quantified information, and reconciliation checks on matters such as project progress payment valuations. All incoming documents are first sighted by senior management (directors) before distribution to project teams.

Regular audit procedures are in place to flush out non-compliances in the company's ISO 9000 system, and post-project analyses are held by the project team leaders to identify and distinguish between non-fatal and fatal non-compliances. Fatal non-compliance is defined as any incident or omission which would leave the company open to a professional liability claim. SIQSI believes that improvement in the company's quality assurance system (and hence in its risk decision making) could be achieved by increasing the level of external review.

The company does not maintain a specific risk register built up from previous projects. However, in the early project briefing meetings with clients, each project is examined on its merits to explore factors critical to the success of that project, as well as to identify missing information. A "Query List No.1" is used for this examination, and this document includes a standard list of information requirements established through experience on previous projects. This document is updated as necessary from the post-project analysis processes mentioned above.

The company directors meet every Monday morning to brainstorm issues relating to current projects and discuss progress.

Project time factors are analysed through reference to the size, scope and type of the project. Cost factors are analysed through reference to available updated historical cost data held by the company, and to budget prices obtained from specialist consultants and/or subcontractors. Project quality factors are analysed through reference to specifications and information from previous projects with similar quality characteristics. Analysis of all three factors is influenced by information obtained through "Query List No.1".

Computer-based risk analysis processes have not been used on the factory, as the project is considered to be straightforward. On other projects, spreadsheet-based modelling is used to investigate financial feasibility, and sensitivity testing is carried out to model uncertainty in variable factors.

Generally, the company, on behalf of its clients, aims to ensure that project risks are transferred contractually as far as possible.

S1QS1 believes he has an intuitive feeling for project risks, but he and S1QS2 emphasised that site visits are essential at the inception of all projects, especially to confirm the proximity of adjoining buildings and other features.

S1QS1 and S1QS2 jointly assessed the professional risk profiles of the other stakeholders on the Tuas project as:

- Client - moderately risk seeking
- Project manager - risk neutral to risk averse
- Architect - risk neutral to risk averse
- Engineer - risk neutral to risk averse
- Quantity surveyor - risk averse
- Contractor - risk seeking

They were not aware of the personal risk profiles of the other stakeholders.

For all projects, S1QS1 believes that regular meetings between stakeholders, particularly after construction starts, help to communicate and deal with risk issues.

Main Contractor

The representative (S1MC) of the main contractor for the factory project was interviewed in the interviewer's hotel room. The interview lasted for approximately one and a quarter hours.

The main contractor is a small but experienced construction company, formed in 1995. Its three directors each have from 11 – 23 years experience in the construction industry. S1MC is the managing director of the company, and is largely responsible for obtaining and organising new work. One co-director has operational responsibility for the company's projects, with day-to-day responsibility for sub-contractors' on-site progress. The other co-director has responsibility for liaison with clients and consultants. S1MC believes that the three directors are each working in

the areas which best match their capabilities. None of them have formal qualifications in building. The organisational structure is shown in Fig. 8.3 and best described as simple and administratively-ordered.

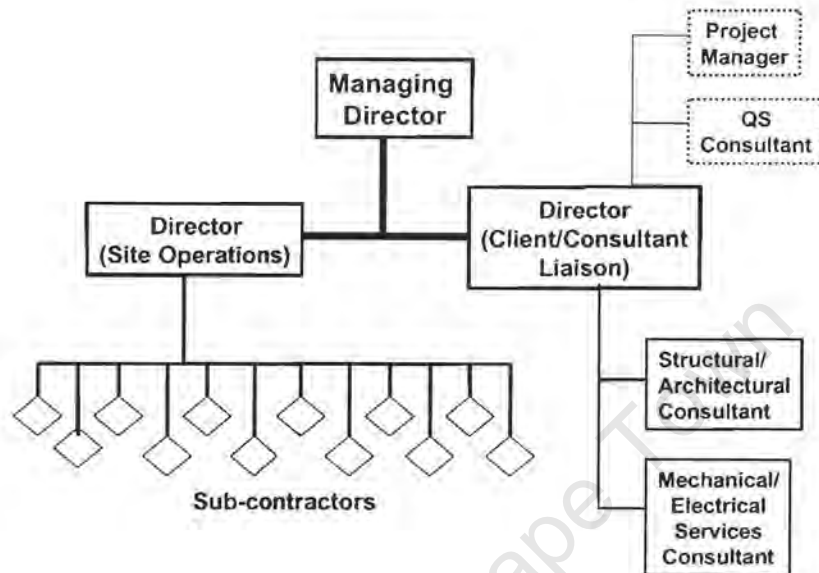


Fig. 8.3. Case S1: Organisational structure for main contractor.

The company sub-contracts all on-site work. SIMC anticipates that about twelve sub-contractors will be used for the factory project, including:

- Piling
- Formwork
- Reinforcement
- Post-tensioning
- Lift installation
- Electrical installation
- Air-conditioning and mechanical installations
- Plumbing and sanitary installations
- Finishes and painting

This is the first design-build project for the main contractor. Based on its track record, the company was included in a selected list of 5 tenderers for the project, and won the bid. SIMC was satisfied with the tendering process, pointing out that open tenders for construction projects in

Singapore had recently each attracted upwards of thirty tenderers, as the market was still very competitive after the end of the economic down-turn in South-East Asia.

The original contract contained a clause allowing the owner (the manufacturing company) to assign the performance bond to a third party without first obtaining the consent of the main contractor. SIMC objected to this clause, as it created an unnecessary area of uncertainty and risk for his company. The clause was removed during negotiation.

SIMC considers the new factory building to be a small, relatively uncomplicated project. No regulatory changes are anticipated which could impact on the project.

The completion deadlines for the project are considered to be severe but manageable, and progress (at the time of the interview) is approximately one month ahead of schedule, as the construction permit was obtained earlier than anticipated.

SIMC believes that time management, cost and quality are the major risk factors on the project. These are dealt with through the design-build procurement system, the fixed price tender, and the agreed specification, respectively.

He identified two specific project risks: the financial security of the client, and piling depths. The former was dealt with by making enquiries (through his company's bankers and accountants) about the client's financial background. As for the latter, soil conditions in Singapore are generally poor, so piling is almost always required. However, piling depths can vary substantially, affecting the price of this work. In this case, the piling sub-contractors were familiar with the project locality, and a piling depth of about 22m was assumed. This has been substantiated by the test pile loading. No other geotechnical investigation has been done. Despite Singapore's high annual rainfall, flooding is no longer considered a site risk as the large diameter storm-drainage systems are installed as early as possible in the construction program.

According to SIMC, his company does not use any standard, formalised approaches to risk management in the organisation. He believes that risks are best managed by having the right people in the organisation and having good relationships with clients and consultants.

The main contractor approaches all projects in the same way. Checks are made on clients and consultants where necessary. No risk brainstorming occurs except where site access difficulties or

new technical features are perceived on projects. The company does not formally record its risk decision-making processes, and post-project analysis is limited to financial reconciliations only.

SIMC believes that the company could improve its organisational decision-making by adopting more forward planning and obtaining project information earlier, as work sequencing is sometimes a problem.

The ultimate responsibility for risk on this project rests with SIMC, who deals with it on an *ad hoc* basis. The project is probably too small to require a more systematic approach. SIMC has had no formal risk management education or training, and relies largely on his extensive project experience.

On the factory project, a simple software program was used to create the bar chart programs, but no computerised risk analysis was used. In SIMC's opinion, the size and simplicity of the project do not warrant more sophisticated techniques.

SIMC identified managerial risks (relating to time, cost and quality factors) and technical risks (equipment failure) as risk events he had experienced on previous projects. However, none had resulted in serious financial loss to the company and all events were managed effectively at the site level.

SIMC believes that the client, the project manager and the quantity surveyor on the factory project are all experienced. He is also satisfied with the experience of the architects, engineers and sub-contractors, as he has worked with all of them at various times on previous projects.

In terms of risk profile, SIMC considers himself to be risk averse in a professional capacity. He believes he has an intuitive feeling for risks on construction projects, developed over years of experience. In his private life SIMC believes he is also risk averse. He thinks that the other participants in the factory project are professionally risk averse, but has no knowledge of their personal risk attitudes.

In the matter of construction risks being passed on down the supply chain, SIMC is aware of the increasing trend of this practice in Singapore, but generally believes that it is unfair. He tries to ensure that his company does not pass risks on to sub-contractors which they may be unaware of or cannot manage. He made the point that "you are either a broker or builder – but not both".

Main contractor's architectural and structural engineering consultant

The architects and structural engineers for Project S1 are a small structural engineering consultancy formed in 1992 by the principal (S1SE), who had previously had 12 years experience in the construction industry since graduating from university with a Bachelor of Engineering degree. S1SE was interviewed in the interviewer's hotel room. The interview lasted approximately 50 minutes.

S1SE is the sole principal of the structural engineering consultancy, and employs two engineers, two draughtsmen and an administrative assistant. The firm's organisational structure is shown in Fig. 8.4. It is an administratively-ordered simple structure.

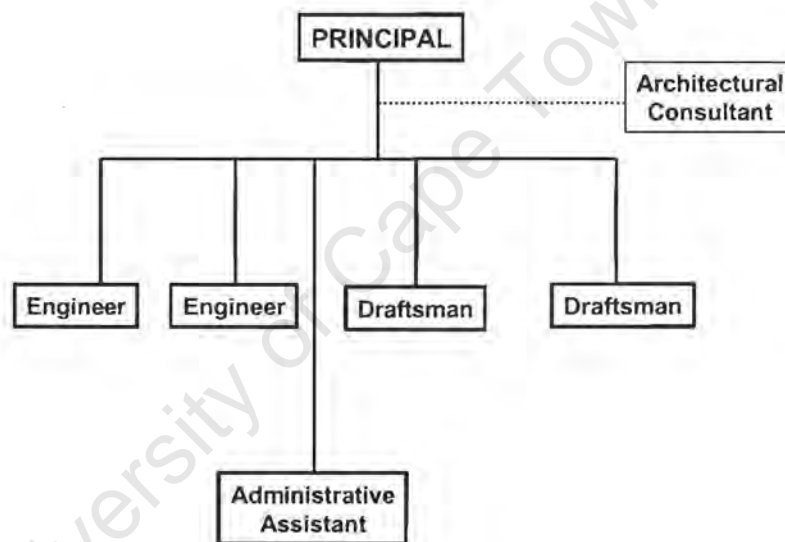


Fig. 8.4. Case S1: Organisational structure for architectural and structural engineering consultant.

In his opinion, the factory project is small and relatively uncomplicated. He employed an architect to provide the architectural design, as part of his consultancy service, following recent changes to government regulations which now allow structural engineers to undertake architectural design on new factory buildings and alterations and additions projects.

S1SE describes the factory structure as a post-tensioned flat slab system with columns founded on bored piles. The structural system was chosen for its cost effectiveness, the ability to

accommodate the large clear spans (exceeding 8m x 8m two way grid) required by the client, and for its speed of construction. Post-tensioning the three main transverse beams allows formwork to be removed just four days after casting. SISE will also design the formwork system and supervise and inspect its erection and removal once he is satisfied that the specified stress limits have been achieved. The detail design and execution of the post-tensioning will be undertaken by a specialist company, according to SISE's specification.

SISE's decision to use this structural system was based upon his own detailed cost comparisons of alternatives, carried out a few years ago. In-situ reinforced concrete was chosen, rather than a prefabricated precast concrete system, as the former is better known in Singapore and the main contractor is more experienced with it.

Bored piling, although more expensive than precast driven piling, was chosen in order to reduce the effect of noise and disturbance on the client's existing factory operations.

Although completion time for the project is tightly constrained, SISE believes it is adequate, and that early completion may even be obtained. He explained that a one month saving in the time required for statutory approvals should contribute significantly to this. This was largely achieved by his having pre-submission consultation meetings with Jurong Town Council officials, to discuss the implications of the clear span and clear height requirements for the factory.

SISE considers that no innovative technology will be required for the construction of the factory, as the post-tensioning system is well known and the specialist is experienced. No regulatory changes are anticipated which could impact on the project. He stated that the design is in accordance with the accepted design codes (for structures and anti-seismic protection of buildings) currently in force for Singapore. These are based upon established British codes.

SISE's firm has worked on previous projects with the main contractor, and with the quantity surveyors.

Additional geotechnical investigation was not considered necessary for the factory project, as SISE and the piling specialists are familiar with ground conditions in this locality.

SISE does not use any standard, formalised approaches to risk management. He personally checks all calculations, and as much of the detailed design as possible, for all work undertaken by his firm. As far as possible, he prefers working on projects where one or more of the stakeholders is

known to him. He does not carry out financial probity checks on new clients, but does make informal enquiries from other participants if he has any doubts.

He does not formally record risk decision-making processes, and post-project analysis is limited to financial reconciliation only.

SISE would like to improve his knowledge of formal risk management, as he has no formal education or training in this field.

The ultimate responsibility for his firm's risk on this project rests with SISE and he deals with it on an *ad hoc* basis.

On the factory project, an engineering design software program was used to carry out the structural design calculations according to the current codes of practice. More sophisticated computerised risk analysis is not considered necessary for the projects he undertakes.

SISE identified one risk situation he had encountered on a previous project. This had involved the design of a large basement excavation where the slope height at one end of the excavation was very steep and high. He was concerned about the lateral thrust from an adjoining building interfering with the stability of the bank, and had consulted a specialist expert to obtain advice about its structural safety before specifying a strict sequence to the excavation process.

SISE believes that the client, the project manager, quantity surveyor and main contractor on the factory project are all experienced. He is also satisfied with the experience of the piling and post-tensioning sub-contractors.

Within his firm, SISE deals with decision-making on a one to one basis with individual staff, brainstorming where necessary to resolve problems. On the factory project, decision-making occurs at meetings between stakeholders, but few meetings have been necessary.

In terms of risk profile, SISE considers himself and his firm to be risk averse in a professional capacity. He believes he has an intuitive feeling for risks on construction projects, developed over years of experience. In his private life SISE believes he is also risk averse. He thinks that the other participants in the factory project are professionally risk averse, but has no knowledge of their personal risk attitudes.

Main contractor's mechanical and electrical engineering consultant.

The mechanical and electrical engineering consultant was not available for interview.

8.2.3. Intra-Project comment.

Project riskiness.

Table 8.1 depicts the tabulated responses of participants to the criteria (Smith, 1999 and Chapter 7) intended to establish the “riskiness” of the S1 factory case study project.

Risk criteria	Project manager (S1PM)	Quantity surveyor (S1QS1)	Quantity surveyor (S1QS2)	Main contractor (S1MC)	Structural consultant (S1SE)
Client business sensitive to project quality, cost or time?	Time.	Time.	Time.	Time.	Time.
New technology or development of existing technology required?	No.	No.	No.	No.	No.
Novel methods required?	No.	No.	No.	No.	No.
Large or complex project?	No.	No.	No.	No.	No.
Extreme time constraint?	Severe.	Severe.	Severe.	Severe.	Severe.
Stakeholders experienced?	Moderately experienced	Yes.	Yes.	Yes (but not in design-build procurement)	Yes (but not in arch. design responsibility)
Project subject to regulatory changes?	No.	No.	No.	No.	No.
Project in a developing country?	No.	No.	No.	No.	No.

Table 8.1. Case S1: Stakeholder perceptions of project “riskiness” criteria.

The completion time required for the project is considered to be severe (rather than extreme) by all interviewees, but responses to the other criteria suggest that it cannot be regarded as a high risk project.

The completion time risk (for the client) has been mitigated by the adoption of a design-build procurement system and by the inclusion of liquidated damages clauses in the contract agreement.

In fact, although the client's business is sensitive to the timely completion of the new factory building, neither project time, nor cost, nor quality (fitness for purpose) are absolutely critical in this case. Since the client is a subsidiary part of a large, diversified holding company, failure to fully achieve any or all of these project objectives would be unlikely to be catastrophic for the parent company.

The main contractor's experience in factory construction appears to have been mistaken for experience in design-build procurement by the client's advisors during the selection process. However, this does not add substantially to the project risks since the contract agreement sets out the contractor's obligations and the project itself is uncomplicated in terms of both design and construction. It is probably just as well that the project is simple as, following upon the regulatory changes made by the Singapore government, it represents the first instance where the consulting structural engineer has taken responsibility for the architectural design. He has mitigated the technical risk this imposes, by employing an architectural sub-consultant to undertake this part of the design work.

While none of these facts, either individually or collectively, would change the view that this case study is not a high risk project, their existence does reveal a matter of concern. The main contractor's inexperience with design-build procurement, and the structural engineer's inexperience with architectural design responsibility, are both unknown to the other project stakeholders, and any risks they entail are similarly obscured.

The factory building project is being undertaken in a period of recovery from economic recession in Singapore. According to the Singapore Department of Statistics (<http://www.singstat.gov.sg>), most sectors of the economy showed a positive growth performance in the third quarter of 2000, with the exception of the construction sector where activity showed a negative change from the previous quarter. The graph of the Tender Price Index (Building and Construction Authority: <http://www.bca.gov.sg>) remained flat for the third successive quarter, after a continuous decline since third quarter of 1997. Market conditions in the construction industry can therefore be described as relatively competitive.

The political and industrial relations environment in Singapore can be described as very stable.

The factory site is located in an existing light industrial area which has no environmentally-sensitive constraints upon building design or construction activity.

Project and stakeholder risk management.

Table 8.2 depicts the summarised responses of the case study participants' responses to interview questions relating to the project and their organisational risk management practices.

Risk management practice aspect	Project S1	Project manager (S1PM)	Quantity surveyor (S1QS1 & 2)	Main contractor (S1MC)	Structural consultant (S1SE)
Formal risk management system in place?	No. <i>Ad hoc</i> approach used.	No. <i>Ad hoc</i> approach used.	No (but ISO 9000 certified).	No. <i>Ad hoc</i> approach used.	No. <i>Ad hoc</i> approach used.
Risk identification processes?	Not explicit. No risk register.	Not explicit. No risk register. Focus upon critical project success factors.	Not explicit. No risk register (but standard query list used). Focus on QA to minimise professional liability.	Not explicit. No risk register. Intuitive experience. Focus mainly on site access, ground conditions, and client financial status.	Not explicit. No risk register. Intuitive experience. Focus on structural integrity of designs.
Risk analysis processes?	No formal or mathematical processes used (except bar chart and cash flow programs).	No formal or mathematical processes used.	No formal or mathematical processes used. Spreadsheet financial modelling when necessary.	No formal or mathematical processes used. Computerised bar-chart project programming.	No formal or mathematical processes used. Computerised structural design calculations.
Responsibility for risk response decisions?	Each stakeholder makes own decisions.	Under client direction.	Project director.	Managing director.	Principal.
Risk monitoring and control processes?	Site meetings.	Focus on critical success factors.	Weekly directors' brainstorming session.	Talk with co-directors as necessary.	Discuss with staff and fellow consultants as necessary.
Possible improvement to risk management practice?	Not applicable.	Faster client decision-making. Fewer client change requests.	Regular project stakeholder meetings	Improve forward planning and information flow.	Better knowledge of formal processes.

Table 8.2. Case S1: Project and stakeholder risk management practices.

Risk management practice aspect	Project S1	Project manager (S1PM)	Quantity surveyor (S1QS1 & 2)	Main contractor (S1MC)	Structural consultant (S1SE)
Barriers to implementing more systematic risk management processes?	Not applicable.	Time and cost for small projects.	Fear of alarming clients.	No comment.	No comment.
Post-contract risk de-briefing process?	Not known but unlikely.	No. Cost reconciliation only.	Internal de-briefing focuses on QA non-compliances.	No. Cost reconciliation only.	No. Cost reconciliation only.
Risk communication media?	Contract agreement. Meeting minutes. Letters, faxes and telephone.	Meeting minutes. Letters, faxes, telephone and e-mail.	Meeting minutes. QA manuals, letters, faxes, telephone and e-mail.	Meeting minutes. Letters, faxes and telephone.	Meeting minutes. Letters, faxes and telephone.

Table 8.2. (Contd.) Case S1: Project and stakeholder risk management practices.

None of the stakeholders interviewed has any formal education or training in risk management, and all rely on their experience and intuition to deal with project risks.

No formal, explicit, systematic process of risk management is used on this project. Nor, with the partial exception of the quantity surveyors, do any of the interviewed project stakeholders exercise formal risk management practices. Instead, partial and *ad hoc* approaches are generally adopted for each project.

The quantity surveying consultant has adopted an accredited quality assurance system for its operational processes, partly to minimise its potential exposure to professional negligence claims, and partly as a marketing device for its services. While this system resembles formal risk management in some respects (recording of processes; checking procedures; system design to minimise non-compliances), its focus is really on the equivalent of risk response and risk monitoring and control. The processes of risk identification and risk analysis are not clearly visible, and the system itself is not dynamic (in a risk management context), since any professional risks for the organisation may have been considered only once, at some point prior to finalisation of the design of the quality assurance system. Nor does the QA system assess the magnitude of risks and prioritise them.

None of the interviewed project stakeholders maintains a formal risk register, although the quantity surveyor's standard project query list (addressed at the commencement of each project) serves a similar check-listing purpose. The query list, however, does not distinguish explicitly between risk and non-risk matters.

The project manager's risk identification focus is upon critical success factors for all projects, and these largely pertain to time, cost and quality issues. For the quantity surveyor, project cost is a critical factor, and risk identification carried out via the standard query list aims to ensure that cost significant issues are not overlooked, although all costs are treated deterministically. For all projects, the main contractor is primarily concerned with issues of site access and site conditions, together with reassurance about the client's financial probity. The structural engineering consultant's risk focus is upon the structural integrity of the project design. None of the interviewees described their *foci* explicitly as risk identification, but saw them as either professional or commercial prudence.

No formal, dedicated risk analysis processes have been used on Project S1, although implicit exploration of the time and cost objective risks has occurred in the project bar chart program and cash flow forecast prepared by the main contractor. The engineer's computerised structural design calculation software is based upon standard design codes which have no transparency with respect to probabilistic data treatment. Spreadsheet-based financial modelling is undertaken by the quantity surveyor, but no probabilistic data treatment is used and sensitivity testing is limited to simple manipulation of specific variable values.

For Project S1, each stakeholder makes his own risk-related decisions with little or no reference to the other stakeholders. The project manager makes these decisions under the direction of the client. For the other interviewees, this decision-making occurs at the strategic apex of each stakeholder organisation (Mintzberg, 1979).

Implicit monitoring and control of project risks (and specifically time-related risks) occurs at project team meetings for Project S1. Prior to construction, these have been sporadic (four meetings over a six-month period). When construction commences, meetings will be more frequent - at weekly intervals during the foundation work; then fortnightly during the construction of the superstructure; and weekly again for the last five to six weeks of the project. Within their own organisations, interviewees tended to adopt an *ad hoc* approach to risk monitoring and

control. An exception was the quantity surveying consultant, where weekly directors' meetings are held to report upon, and brainstorm, project issues.

None of the interviewees offered suggestions for improving risk management practice *per se* within their own organisations, although the structural engineer thought that better knowledge of risk management itself might help. Interviewees tended to make suggestions which would actually reduce or avoid risks, despite being asked to consider the question in the context of a systematic approach to risk management.

Nor could interviewees easily identify barriers to implementing more systematic risk management processes. Excessive time and cost for small projects was thought to be a possible barrier, but the interviewee was reluctant to suggest what time and what cost limits might be considered acceptable. The quantity surveyors thought that implementing and explicitly labelling a risk management system (either on individual projects or organisationally) might cause alarm among clients, and would certainly lack the softer, more marketable image of an accredited quality assurance system.

Within their own organisations, most interviewees limited their post-project de-briefing processes to cost reconciliation. For the quantity surveyors, this was an integral part of their client service, and their de-briefing was aimed at identifying any non-compliance incidents in terms of their internal QA system.

The contract agreement was the only explicit risk communication medium identified by interviewees on Project S1, and more specifically the clauses relating to the contract period. Implicit communication about project and organisational risk was thought to occur in most other forms of communication, including minutes of meetings, letters, faxes, telephone calls and e-mail messages, where these dealt with problems or constraints of the project. The quantity surveyors considered their QA manual to be explicit about organisational risks.

Overall, the findings about risk management practice to be drawn from the interviews with Project S1 stakeholders are that:

- Neither the project, nor any of its stakeholders, has adopted formal and systematic risk management processes.
- Risk identification processes are limited to critical project success factors (client representative); professional services required (consultants); and operational and payment factors (contractor).

- Little or no project or stakeholder organisational risk analysis is carried out.
- A limited amount of risk monitoring and control takes place on the project and in the stakeholder organisations.
- Little risk de-briefing occurs after projects have been completed.
- Stakeholders have a relatively weak understanding of formal risk management, and hence do not see clear benefits from (or barriers to) implementing risk management systems on the project or in their own organisations.
- A shared understanding of a few project risks may be attained through the formal contract agreement, but the implicit nature of risk communication in other media suggests that this may not be so for all risks on all projects and within all organisations.

Implications of organisational structure.

The organisational structures identified within case study Project S1 comprise:

- Project: temporary, administratively-ordered simply structured professional bureaucracy.
- Project manager: administratively-ordered simple structure.
- Quantity surveyors: administratively-ordered divisionalised professional bureaucracy.
- Main contractor: administratively-ordered simple structure.
- Structural engineer: administratively-ordered simple structure.

These structures raise few issues for risk management for the project or for the stakeholders. The simple structures for the project and for the contractor and structural engineer should be advantageous in terms of centralisation and short communication lines for strategic and operational decisions; flexibility; and focus on objectives (Mintzberg, 1979). For the structural engineer particularly, and for the main contractor to some extent, this simplicity, with its vertical and horizontal centralisation, means that their organisations (and hence the project itself) are particularly vulnerable to any sudden loss or incapacity of the principals.

A divisionalised structure often entails long communication paths, usually with decision-making power located at the highest levels (senior managers, executive directors, etc.). However, in the case of the quantity surveyor these disadvantages have been largely avoided. Project teams (the divisions) are relatively small and report straight to project directors with decision-making power.

The project and stakeholder organisations are all administratively-ordered, since they are more concerned with commonality of objectives, structure, hierarchy, function, control and adaptability than with meaning, power, politics and symbolism (Parkin, 1996). There is therefore little or no dissonance between structure and ordering within the project and stakeholder organisations for Project S1.

Risk profiling.

Interviewees were asked to first describe their professional risk profiles; then their personal risk profiles, and finally to venture an opinion about the professional and personal risk profiles of other stakeholders in the project. The questions were not framed in terms of any psychometric tests for risk profiling (eg. Greenwood, 1997; Raftery, 1993), since there was no research objective to measure individual profiles and, in any event, it was thought to be more useful for this research to discover if participants needed any help in understanding what was being asked. None of the interviewees had previously undergone psychometric risk profiling analysis.

Interestingly, no interviewees on this case study asked for help in elucidating professional risk profiles, and views on these were offered without hesitation. Interviewees were less sure about personal risk profiles, and one participant suggested that sub-categorisation of personal risk profiles might be necessary (eg. financial, family and leisure). This suggests that participants, by virtue of their training and experience, tended to have decided views about their capacity to make professional judgements, but were sometimes less sure, and less consistent, about personal judgements, depending on the context.

The interviewees' perceptions of their own risk profiles (professional and personal) are shown in Table 8.3.

Table 8.4, read horizontally across each row, displays interviewees' perceptions of the professional risk profiles of other project stakeholders. None of the interviewees was prepared to offer an opinion of the personal risk profiles of others.

Contrary to the views of other participants, the quantity surveyors thought that the main contractor was professionally risk seeking, but they were more tentative about the professional risk profiles of other stakeholders.

Risk Profile	Project manager (S1PM)	Quantity surveyor (S1QS1)	Quantity surveyor (S1QS2)	Main contractor (S1MC)	Structural consultant (S1SE)
Professional risk profile.	Risk averse.	Risk averse.	Risk averse.	Risk averse.	Risk averse.
Personal risk profile.	Risk seeking in leisure activity.	Moderately risk seeking in personal finance.	Risk averse in all aspects.	Risk averse in all aspects.	Risk averse in all aspects.

Table 8.3. Case S1: Stakeholder perceptions of their own risk profiles.

Stakeholder:	Client*	Project manager (S1PM)	Quantity surveyor (S1QS1 & 2)	Main contractor (S1MC)	Structural consultant (S1SE)
Client*	≡	≡	≡	≡	≡
Project manager (S1PM)	Risk averse.	≡	Risk averse.	Risk averse.	Risk averse.
Quantity surveyor (S1QS1 & 2)	Moderately risk averse.	Risk neutral to risk averse.	≡	Risk seeking.	Risk neutral to risk averse.
Main contractor (S1MC)	Risk averse.	Risk averse.	Risk averse.	≡	Risk averse.
Structural consultant (S1SE)	Risk averse.	Risk averse.	Risk averse.	Risk averse.	≡

*NB. Client view not obtained.

Table 8.4. Case S1: Stakeholder perceptions of other stakeholders' professional risk profiles.

These findings suggest that individual risk profiling may have a limited usefulness, in that culture and custom might imbue stakeholders with pre-formed perceptions of other stakeholders. It may also be that personal risk profiles are unrelated to, and do not impact upon, professional risk profiles, but the data of this research do not allow that to be stated categorically.

Risk “stories”.

Only one interviewee (structural engineer) recounted a previous risk experience. He has since applied the knowledge gained to other projects involving complex ground excavations. Strictly speaking, this was not a risk *event* experience, as an adverse event did not actually occur. A risk was identified, and action taken to reduce both the probability of occurrence and likely impact.

The paucity of individual risk “stories” in this case study has to be set against interviewees’ claims to deal with risks on the basis of experience and intuition. It may be that actual risk events are perceived by stakeholders as representing some form of personal failure, giving rise to a subsequent reluctance to recall them. In the case of Project S1, Chinese cultural influences might have exacerbated this reluctance. This problem was partially addressed by inviting interviewees to select risks from the given list, thus providing them with an opportunity to recall risk events with which they had had no direct involvement. In retrospect, this may not have been effective, since there could also have been a similar reluctance to “implicate” fellow professionals in the risk stories. The findings from the other case studies should shed light on this.

8.3. Case SA1

8.3.1. Project description

The first South African case study is a new information technology centre project for a Technikon, located at Bellville South in Cape Town.

The project objective is to create the essential physical environment and facilities for raising computer literacy among the college students.

The building is intended to house multiple work stations (+/- 1500) for unstructured as well as tutored student use, together with a literacy and writing centre, video-conferencing unit and studio facilities. It will serve all faculties (Engineering, Business and Science) of the college. The project organisational structure, shown in Fig.8.5, is an administratively-ordered, simply-structured, professional bureaucracy.

A conventional separated procurement system is used for the project (design and document, tender, construction), mainly because the college authorities are familiar with this traditional approach and have used it on all development projects so far. However, the piling will be done

under a separate contract, and there will be several selected (nominated) subcontractors appointed under the main building contract. A separate negotiated contract will also be used for the tensile membrane roof. This method allowed the project brief to evolve in step with the design. A full brief was not possible at the start of the project (compared to other educational buildings where spatial requirements and functions could be clearly identified and quantified early in the planning process) since no comparable buildings could be identified as models for the new centre. In a sense, it started as a shell, whose overall dimensional constraints were known. Subsequent identification of the resource requirements for IT literacy, through consultation with staff and students, enabled more detailed spatial planning to go ahead.

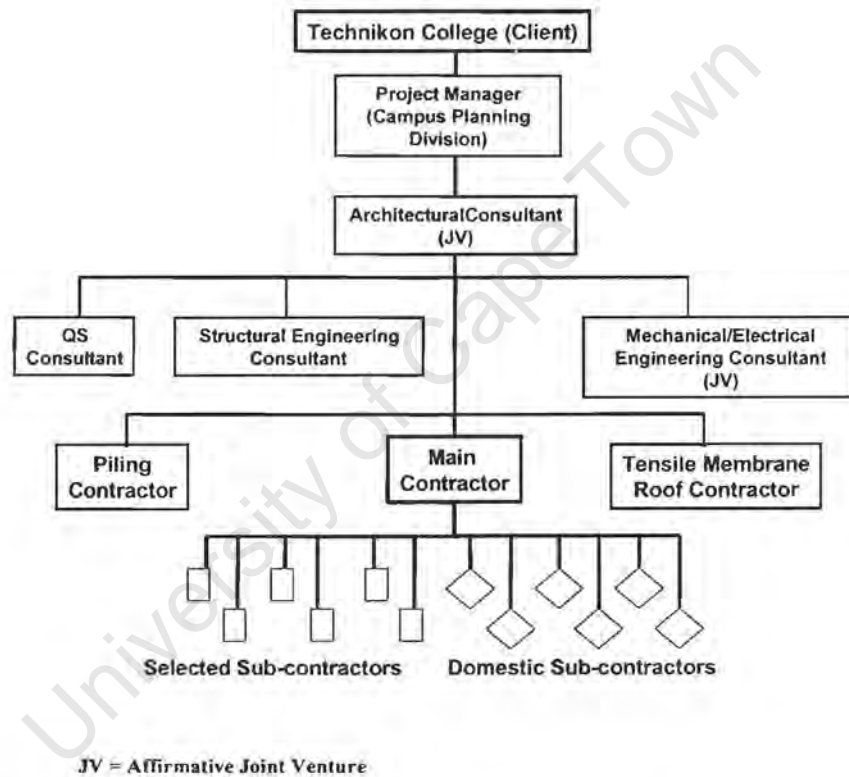


Fig. 8.5. Case SA1: Project organisational structure.

The proposed IT Centre is a three storey building with a gross floor area of 6590 m², and has a simple rectangular shape. It is founded on precast driven piles, and has a reinforced concrete structure comprising columns and external beams and coffered floor slabs. The coffer slab design was chosen because of client preference and because of its lower noise transmission factor, compared to a conventional flat thin slab and beam structure. The roof covering is clay tiles on double pitched timber trusses. Infill walls are brick hollow walls with facing bricks externally and plaster finishes internally. Glazed aluminium windows and doors are used externally. Simple carpet and tile finishes are used internally. The style of the building matches the co-ordinated

theme developed for campus buildings generally, although a tensile membrane roof will be used over the atrium section, rather than the glazed northlight saw-tooth type atrium roofs used on other buildings. This will signify the advanced technological use of the building.

Because of the noise and vibration, and the proximity of other campus buildings, the piling must be carried out immediately after the October 2000 examination period, and completed before the end of November.

The construction period (including piling) is scheduled to start in October 2000, and the building is to be completed ready for occupation by the end of December 2001.

A cost limit of ZAR26 million, including escalation allowance, 14% VAT, professional fees and desk fittings, etc. but excluding computer equipment and software, has been set for the project. This figure is based upon the quantity surveyor's detailed cost estimates.

In terms of the current political and sociological policies of the South African government, the project procurement system includes conditions relating to the empowerment and uplifting of previously disadvantaged population groups. Specifically this has led to an affirmative joint venture between two firms for the provision of professional architectural consultancy services, and a similar joint venture for the mechanical and electrical consultancy service. The structural engineering and quantity surveying consultancies already had affirmative action measures in place. At the time of conducting interviews, project documentation was about to be issued for pre-qualifying tenderers. This would ensure that tendering contractors would also have suitable empowerment structures and practices implemented within their organisations and within their subcontractors.

8.3.2. Interview summaries

Project Manager

The project manager (SAIPM) for the Technikon information technology centre project was interviewed in his campus office. The interview lasted two and a quarter hours.

SAIPM is the client's representative, and acts as project manager on their behalf. He is an architect by training, and has worked in the Campus Planning Division of the Technikon for 12 years. He has more than 20 years experience in the construction industry in South Africa.

The client/project manager organisational structure is shown in Fig. 8.6. It is an administratively ordered professional bureaucracy.

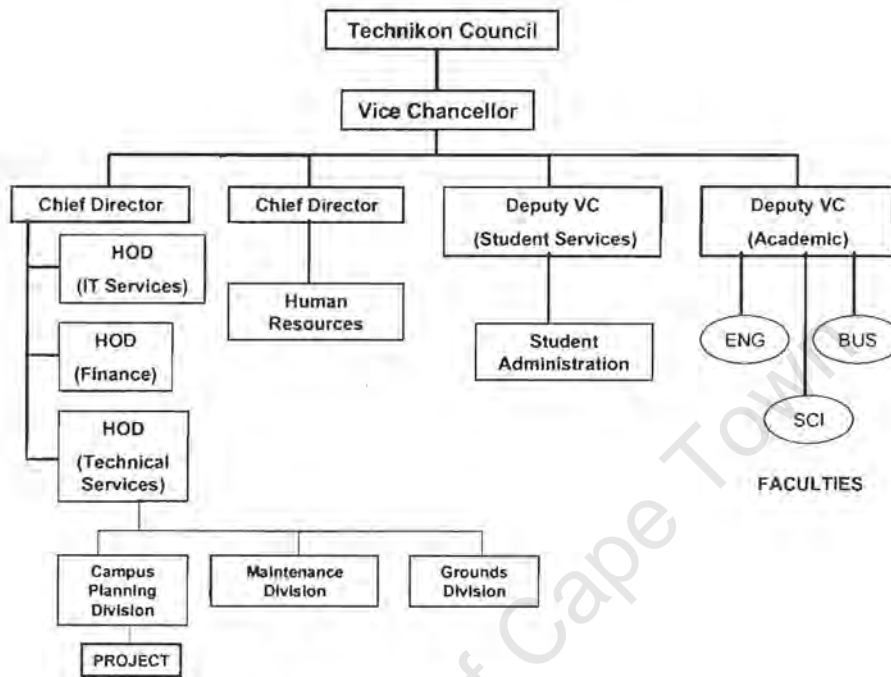


Fig. 8.6. Case SA1: Client/project manager organisational structure.

In SA1PM's opinion, the project outcome is sensitive to all three factors of time, cost and quality (fitness for purpose). The completion deadline for the project is severe, as occupational use is required in January 2002. Compared to other campus buildings, the proposed computer centre is of average size and complexity. The tensile roof membrane will be a novel feature, and the electrical configuration is complex. These factors are likely to impact upon the fire protection requirements for the building.

SA1PM considers the other project stakeholders to be adequately experienced, particularly where the joint venture consultancy arrangements exist on the project. He made the point that, while the objective of these arrangements is that of affirmative action, it is also intrinsically a matter of risk management, by relying on the benefit of the experience of the well-established partners in the joint ventures. Similar empowerment and training opportunity clauses will be used in the contract agreement with the main contractor.

SAIPM has worked on other Technikon projects with the quantity surveyors and the mechanical and electrical services consultants, and the architects have previously worked with the structural engineers.

None of the activities of the Campus Planning Division are currently subjected to explicit risk management procedures. The main risk focus on this project has been cost risk, as the cost limit is regarded by the client as absolute and final. SAIPM believes that risk management is implicit in many of his activities, but he also thinks that the client's decision-making could be improved, both at a project level and in other core activities, by introducing a more formal and systematic approach to risk management. He personally has had no formal education or training in risk management, but is currently undertaking a master's degree in project management at a local university, which includes a part-module dealing with risk, and intends to attend a further seminar on risk management (to be organised by a commercial company) later this year.

Risks on this project have not been formally identified as risks, but have arisen basically in terms of issues relating to time, cost and quality. One risk, escalation in cost, was analysed using an inflation trend line, and an allowance was included in the budget. Another risk was fitness for purpose, and lengthy discussion was held about the flexibility of future use of the building when student computer literacy is no longer such an urgent issue.

The Campus Planning Division does not maintain any formal risk register. No computerised risk analysis has been carried out on the project. The project team did get together often during the planning phase to brainstorm issues and design concepts, but these were not seen as explicit risks to the project.

On the IT centre project, project risks are not dealt with through formal meeting agendas, neither on an intra-departmental basis nor on an intra-project basis, but are usually implied in the problems/issues raised. No formal risk management communication media are used. Project progress reports deal with feedback on problems and issues.

SAIPM did not identify any past risk events, but considers he has an intuitive feeling for risks on this project, based upon his experience with previous projects. He believes it is appropriate to pass risks down the supply chain where the eventual risk-taker is able to control the factors affecting that risk, but not where the eventual risk-taker has no control over events.

SA1PM does not consider himself as risk averse, but will only accept risk on an informed basis. In his personal life he believes that he is becoming more risk averse with age. He thinks that the project architects are professionally risk seeking, while the client, quantity surveyor and the consulting engineers are all professionally risk averse. He has no knowledge of their personal risk attitudes.

Architects

A director of one of the joint venture architects (SA1A) for the IT centre project was interviewed in his city office. The interview lasted one and half hours. The other joint venture partner could not be interviewed in Cape Town as he was overseas at the time. The consultancy organisational structure, shown in Fig. 8.7, resembles an administratively-ordered, simply structured, professional bureaucracy (JV1) in combination with a simple structure (JV2).

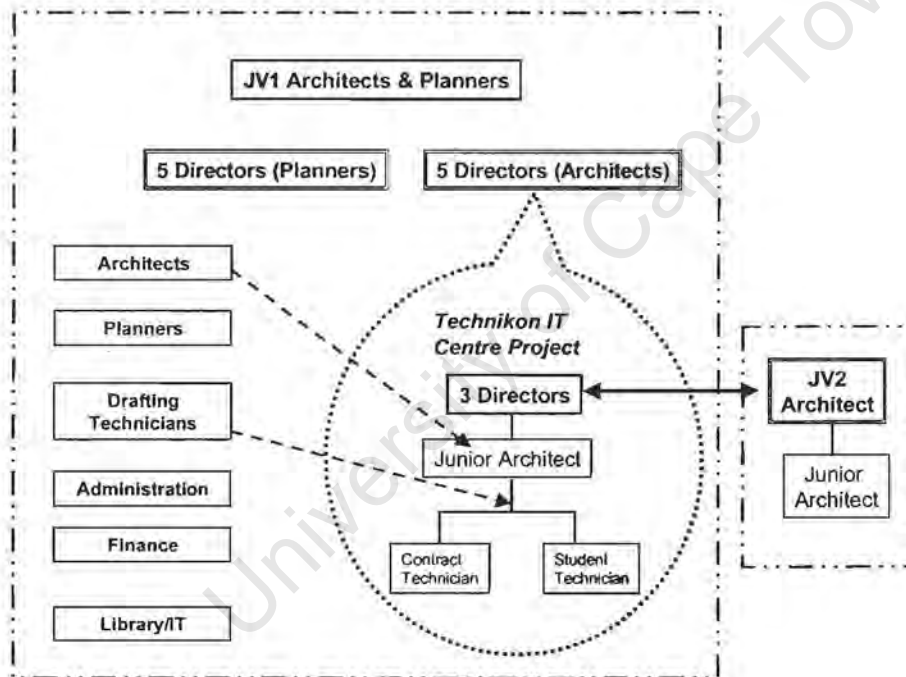


Fig. 8.7. Case SA1: Organisational structure of architectural joint venture consultancy.

SA1A thinks that, compared to other building projects undertaken by his company, the IT centre project is large in size, but average in complexity. He considers that the completion deadline for the project is severe.

The South African National Building Regulations apply to this project. Negotiation with the Fire Officer was necessary to interpret the regulations so that the building could be classed as a

standard building for fire protection purposes and thus avoid the necessity for a sprinkler installation to the tensile membrane roof area.

SAIA considers the other project stakeholders to be adequately experienced, particularly where the joint venture consultancy arrangements exist on the project. The five architectural directors of JV1, and the director of JV2, are all registered architects. SAIA has some concern about the basis for the quantity surveyor's latest cost estimates, in that they appear to include only the same level of detail and price rates as the preliminary estimates. His firm has worked satisfactorily with the structural, and the mechanical and electrical, engineering consultants before.

The joint venture with the second architectural firm (JV2) is on the basis of each partner being reimbursed direct costs, and a 50% profit sharing. The JV uses a special letterhead. All project correspondence is addressed to the client (Campus Planning Department at the Technikon) in the first instance, with copies to the relevant parties. SAIA noted that his firm had been trying to get onto the Technikon's list of preferred consultants for some time, and had formed the Joint Venture as part of a deliberate strategy to achieve this.

None of the activities of JV1 are currently explicitly subjected to risk management, neither generally nor specifically on this project. Within the firm, regular project reviews are held on Mondays, to critique and brainstorm concepts, issues and problems. Similar mini-reviews are held on individual projects within the project team as necessary. Decisions arising from these reviews are not normally recorded formally, but outcomes usually end up as part of the project "as built" drawings or operational manuals. SAIA would like to see this decision process become more formalised, particularly in view of the professional liability issues noted below.

Risks on this project have not been formally identified as risks, but have arisen basically in terms of issues relating to time, cost and quality. SAIA noted the lack of a comprehensive project brief for the IT centre, and the subsequent effort to develop an effective brief.

His firm does not maintain any explicit risk register. No computerised risk analysis has been carried out on the project, and risk management is *ad hoc* rather than systematic, although the practice will only sanction innovative features (eg. the tensile membrane roof) on a fully informed basis.

SAIA did not identify any past risk events, but pointed to many of the listed risks as being applicable in the current construction industry in South Africa. He spoke about the vulnerability

of professional consultants, particularly architects, in a climate of increasing readiness by clients to engage in litigation. Clients are more aggressive, and less prepared to negotiate amicably, over perceived faults and shortcomings in their completed buildings. Similarly, contractors are less prepared to interpret drawings and specifications in a reasonably competent manner. In many instances this has led to JVI having to prepare additional isometric working details, instead of relying on the contractor's tradesmen to interpret correctly from two-dimensional sections.

SAIA's firm has recently re-negotiated its professional liability indemnity insurance, due to the rapidly rising costs of premiums. They now have to accept a R50 000.00 excess on any claim. Each JV partner for the IT centre project has notified its insurer of the 50/50 JV liability arrangement.

SAIA has had no formal education or training in risk management, although he pointed out that a thorough knowledge of the building contract provides a good understanding of risk and its allocation. He considers himself as risk averse, professionally and personally. He thinks that the other project stakeholders are all professionally risk averse. He has no knowledge of their personal risk attitudes.

Quantity Surveyors

An associate partner (SAIQS) of the quantity surveying consultant was interviewed in his city office. The interview lasted one and a quarter hours. SAIQS is a member of the Association of South African Quantity Surveyors and a registered quantity surveyor.

The organisational structure for the quantity surveying consultancy is as shown in Fig. 8.8. It resembles an administratively-ordered divisionalised professional bureaucracy. The Cape Town office is one of six autonomous branches in South Africa, and the company has a loose association with a Canadian quantity surveying firm. It has been in existence for about ten years, and is currently considering expansion of its activities, primarily in the field of project management, into other countries in continental Africa.

Project teams are made up from the pool of staff within the consultancy firm. This allows staff to gain a wider variety of project experience with different colleagues, an arrangement which SAIQS considers better than having fixed project teams.

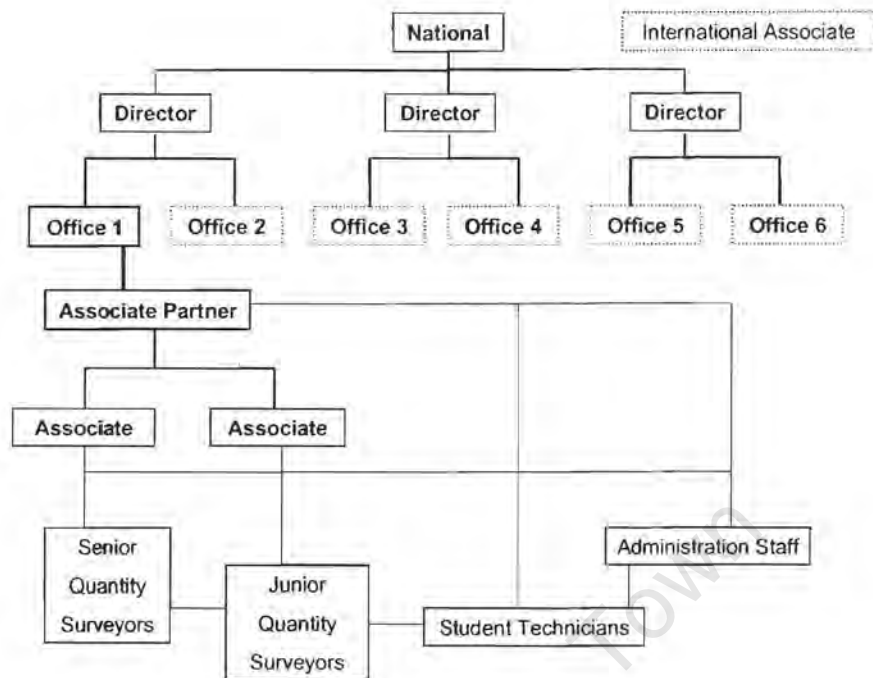


Fig. 8.8. Case SA1: Organisational structure for quantity surveying consultant.

For the quantity surveying consultant, the project outcome is sensitive to all three factors of time, cost and quality (fitness for purpose). SA1QS ranks cost as the first priority and quality as the second. The completion deadline for the project is severe, as occupational use is required in January 2002, but SA1QS noted that two or even three weeks delay in achieving this would not be catastrophic, as the facility is primarily intended for unstructured computer access for students rather than as scheduled teaching space.

Compared to other building projects undertaken by the quantity surveyors the computer centre is average in size and simple in complexity, but SA1QS noted that the lack of a full brief at the outset of the project made the preparation of the initial estimates a difficult task, forcing him to use a high design contingency allowance. This was subsequently reduced as the design information was amplified. He stated that the main reasons for using a reinforced concrete coffered slab construction on the project are that it is considered "flavour of the month" in the region, and that it allows an exposed ceiling finish. He intimated that the tensile roof membrane may have to be replaced with a cheaper alternative in order to keep to the project cost limit, but that a decision on this will be delayed until later in the construction period, when the financial situation of the project is more clearly defined. As a matter of prudence he prefers to have all cost

issues settled early in the project, but will always try to have a "hidden" contingency available to counter any unforeseen cost surprises that may arise later.

SAIQS noted that there will be a pre-qualification tendering phase to ensure that the selected tenderers for the project comply with current empowerment guidelines for public sector contracts in South Africa. These set out the targets which contractors should achieve in terms of employment and training provision for population groups previously disadvantaged under the former apartheid-based government, as well as the tender preference percentage allowed to fully-compliant contractors. The pre-qualification documentation was about to be issued by his office.

At the quantity surveyor's instigation, the main contract agreement will include a clause requiring the contractor to be part of the project cost control team, i.e. the contractor will also have a cost monitoring and early reporting responsibility to the client through the quantity surveyor. SAIQS reports through the architect as they are the principal consultant, but also reports directly to the client on all project cost matters.

SAIQS considers the other project stakeholders to be adequately experienced, although he has some concern about the mechanical and electrical consultants, arising from previous experience with them. He has worked satisfactorily before with the client, both of the joint venture architects, and the structural engineering consultant.

SAIQS believes that project cost over-run is the primary risk which the quantity surveying consultancy faces. This is not dealt with through a formal risk management process, but on every project elemental cost plans are prepared to component level. The cost plan is also included as an agenda item at every project meeting and the outcomes of any discussions are recorded in the minutes of those meetings. Minutes are not formally signed off, but participants are asked to raise any comments at the next meeting, and absence of comment is taken as agreement.

The estimate drawings are used for comparison with every subsequent drawing issue and revision, and cost estimates are immediately adjusted where necessary and notified to the client for sanction. All variation orders and site orders must be costed before being sanctioned by the architect.

The quantity surveyors conduct internal checks, on bulk measurements and price rates, on all estimates prepared in the office. Cost data are mainly sourced in-house, or obtained from the other South African offices if necessary.

Continuous cost monitoring is undertaken on all projects as noted above. All projects are subjected to post-contract cost reconciliation analysis, and are used to augment the firm's cost database. No formal post-project risk decision analysis is carried out.

On Friday afternoons, all employees and directors gather in the firm's board room and hold informal seminars on various issues, mostly relating to the standard form of contract.

SAIQS would like to adopt ISO 9001 in the firm, both as a formal mechanism of quality assurance and as a marketing tool.

On the IT centre project, he believes that each participant takes care of his own risks, and that the project risk management process is therefore individual and *ad hoc*. This individuality prevents the process from being more systematic.

SAIQS has had no formal education or training in risk management, nor has any other member of his staff. He counts his 28 years of industry experience as a valuable teacher in terms of risk.

Risks on this project have not been formally identified as risks, but have arisen basically in terms of issues relating to time, cost and quality.

His firm does not maintain any explicit risk register. No computerised risk analysis has been carried out on the project, but the project estimating models and processes are computerised. SAIQS pointed out that the Friday afternoon seminars held in the office also act as brainstorming sessions, particularly in terms of risk allocation through the contract clauses. These sessions are also used for problem-solving on current projects. Within the quantity surveying firm, no formal meeting processes are used to address project risks, but within the projects themselves the team meeting and site meeting agendas and minutes are used to record all project decision-making.

SAIQS identified a number of past potential risk events, largely arising through design error on the part of other consultants, such as inadequate headroom in a basement parking structure, lack of services co-ordination, and failure to fully specify waterproofing material. In his opinion, the standard of architectural drawings and specifications had declined substantially over the past ten years, but he noted that the checking procedures in his firm had enabled all these errors to be detected before the risks actually eventuated.

Within the quantity surveying firm, a feasibility study for a recent commercial project had produced an acceptable internal rate of return, but the directors were concerned about the accuracy of the input values used by the inexperienced staff member undertaking the study. Further checking revealed that errors in the figures were self-cancelling, and correcting them produced a similar rate of return. SAIQS suggested that this was evidence of an intuitive feeling for risks, based upon years of experience. He also noted that the staff member concerned, after that learning experience, was now entrusted with most of the feasibility study work of the practice.

From the given catalogue of risks, SAIQS also identified risk experiences relating to several other categories including:

- Natural risks such as earthquake occurrence and geotechnical anomaly.
- Human social risks such as theft and marijuana abuse.
- Political risk of riot.
- Economic risk of equipment availability, especially for piling rigs and high capacity cranes, and deterioration in exchange rates for imported components such as lifts.
- Managerial risks such as availability or loss of key staff.

Most of these, except riot, still constitute risks to projects in his opinion. He noted that contractors are more vigilant about site security and health and safety these days. Careful pre-planning helps to mitigate the risk of equipment availability, but other events can still frustrate good planning. Pre-purchasing helps to avoid the exchange rate risk, but some clients are reluctant to accept the earlier cash flow payments this involves. Acquiring and keeping key staff is a constant problem for consultants and contractors. SAIQS tries to maintain a "family" atmosphere in his office to mitigate this risk.

SAIQS believes that where no party is in a better position to manage a particular risk, then it should be borne by the client. Otherwise risks may legitimately be passed down the supply chain to the party best able to control them, but not to the detriment of parties who cannot deal with them. The risk of unexpected adverse ground conditions, for example, should not be passed on where no party is in a position to be better informed about the likely nature of the soil to be encountered. On the other hand, he would expect most contractors to be reasonably well informed about ground conditions in their usual area of operations in the Western Cape.

SAIQS considers himself to be professionally and personally risk averse. He thinks that the other project stakeholders are all likely to be professionally risk neutral. He has no knowledge of their personal risk attitudes.

Structural Engineer

The structural engineer for the project (SAISE) was interviewed in his city office in Cape Town. The interview lasted one and a quarter hours. The organisational structure for the structural engineering consultancy, shown in Fig. 8.9, is an administratively-ordered professional bureaucracy.

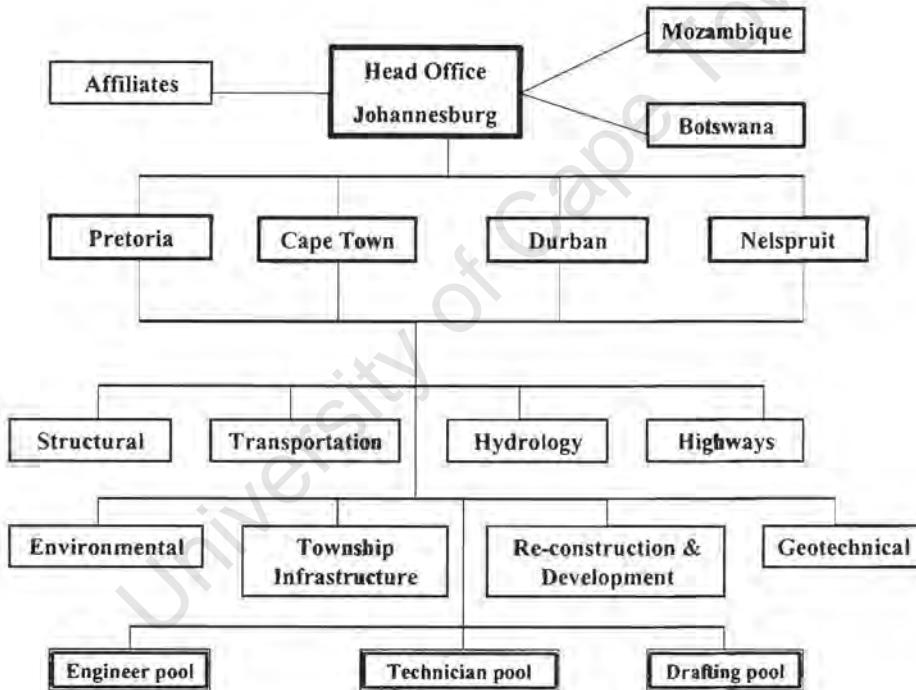


Fig. 8.9. Case SA1: Organisational structure for structural engineering consultant.

The Cape Town office is one of five autonomous branches in South Africa. In addition, there are offices covering Botswana and Mozambique, and the company is affiliated with several specialist engineering laboratory and engineering management companies. The company is headed by a chairman, managing director, two directors and three associates. It has been in existence since 1986, and has undertaken several international projects, including bridges in Malaysia. The company is organised in terms of eight specialised engineering disciplines. Key staff will travel to

wherever their skills are required, and the offices serve as project administration centres, each lead by an office manager. SAISE is the manager of the Cape Town office. He is a qualified professional engineer.

On the computer centre project, the structural engineering consultant is responsible for the structural design and for auditing the specialist's design of the tensile membrane roof.

In SAISE's opinion, the project outcome is most sensitive to quality (fitness for purpose). Compared to other building projects undertaken by his company it is average in size and straightforward in complexity. The completion deadline for the project is tight but achievable.

SAISE considers the other project stakeholders to be adequately experienced. He has worked satisfactorily with the second joint venture architect and the quantity surveyor before.

SAISE believes that design failure, including fitness for purpose, is the primary risk which the structural engineering consultancy faces. This is not dealt with through a formal risk management process, but on every project review meetings are held weekly on Fridays. Minutes of these meetings, which are used to report progress and brainstorm issues, etc., are written up and circulated to all staff.

Inward correspondence is first seen by SAISE, and then passed to the relevant project leaders. All outward documents are signed off by the project engineer and the project leader, and then sighted by SAISE before leaving the office.

The implementation of ISO 9001 is currently under consideration, both as a formal mechanism of quality assurance and as a marketing tool. Cost of implementation is not an issue; it is more a matter of logistics.

On the IT centre project, and on all projects handled by the Cape Town office, project risks are first considered by the team leader and then notified to SAISE, who takes the responsibility for resolving them. He believes this process is more systematic than *ad hoc*. The adoption of ISO 9001 will make the process even more systematic.

SAISE has had no formal education or training in risk management, nor has any other member of his staff. A director from the Johannesburg office undertakes hazard/risk assessment where this is specifically required by project clients.

The consultancy does not maintain any explicit risk register, and no formal post-project risk decision analysis is carried out, but all projects are reviewed after completion and the post-mortem issues are recorded.

Computerised structural calculations have been carried out on the IT centre project, and these include range value outcomes where appropriate, but not probabilities:

SAISE identified a previous risk event, on a project where his company, acting as principal consultants, had predicted industrial unrest on site and had advised the contractor to initiate negotiation with the leaders. No prior risk action was taken but, when a strike subsequently started, he was called in to mediate between workers and the contractor's management.

SAISE believes he has an intuitive feeling for risks, based upon experience, but noted that other staff were probably more consistent in this area.

SAISE considers himself to be professionally and personally tending towards risk seeking. As the manager of the local office, he is committed to seeking all types of projects for his company (rather than limiting the range of work), and enjoys an element of danger in his leisure and sporting activities (water-skiing and snow-boarding). He thinks that the other project stakeholders are all likely to be professionally risk averse. He has no knowledge of their personal risk attitudes.

Mechanical and Electrical Engineers

The mechanical and electrical engineers for the project are an affirmative action joint venture responsible for the airconditioning and electrical engineering design. A director of the second joint venture partner (SAIME) was interviewed in his city office. The interview lasted one and a quarter hours. The joint venture organisation of the consultancy is shown in Fig. 8.10. It is a combination of two administratively-ordered, simply-structured professional bureaucracies.

One affirmative joint venture partner's Cape Town office has been established for two years, and is an offshoot of the other joint venture partner, which is a well established firm with several offices in South Africa. The joint venture is a 50/50 association. Each partner firm claims its direct costs, and any profit will be shared equally. All directors are registered engineers.

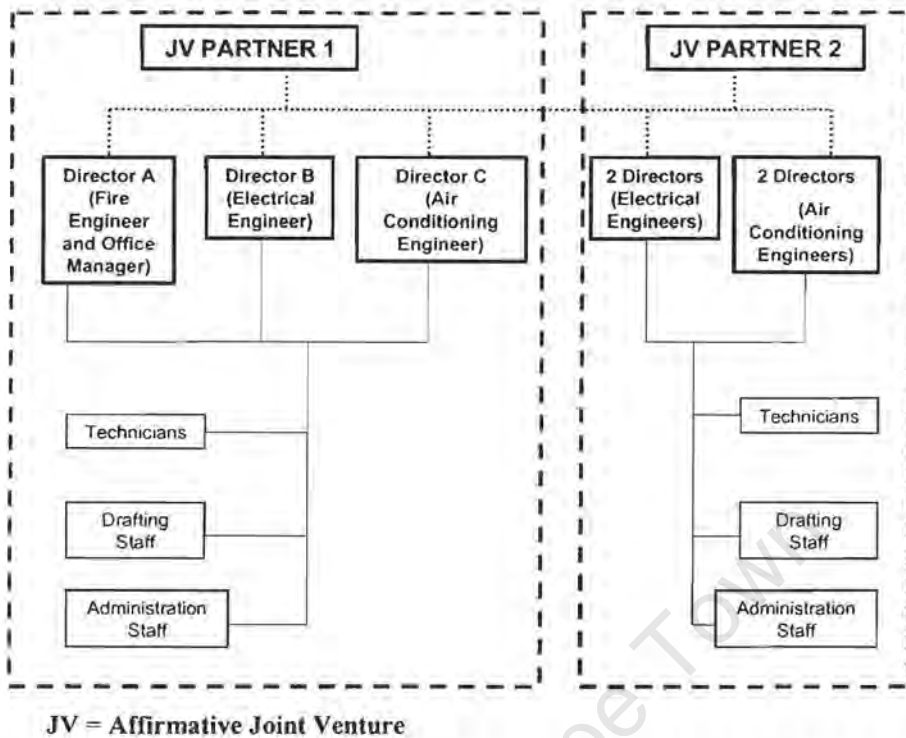


Fig. 8.10. Case SA1: Organisational structure for mechanical and electrical engineering joint venture consultancy.

In SA1ME's opinion, the project outcome is most sensitive to cost. Compared to other building projects undertaken by his company it is average in size and straightforward in complexity. The completion deadline for the project is critical for the client.

The project does not require any new technology for the services installations, and he is not aware of any regulatory changes which could impact the project.

SA1ME considers the other project stakeholders to be adequately experienced. He has worked satisfactorily with the second joint venture architect and the quantity surveyor before.

Neither partner uses a formal risk management process, but on every project budgets and design concepts are reviewed by the staff of the other JV partner. Signing powers are limited to the designated office director for each JV partner. A standard approach is used for all projects, as procedures are laid down in office operation manuals which deal with inception, design, reporting and monitoring tasks.

No formal post-project risk decision analysis is carried out, but client feedback is sought on all projects for both system performance and the consultancy's service performance. In addition, the two JV partners have developed monthly "mechanical meetings" which are run as informal seminars to "red flag" products, suppliers or sub-contractors which are troublesome or inadequate.

The implementation of ISO 9001 is currently under way by one JV partner and under consideration by the other.

On the IT centre project, and on all projects, project risks are first considered by the team leader. For the IT centre, consideration of capacity and flexibility for future changes in use were major issues to be addressed in terms of the technical design.

SAIME believes their processes are more systematic than *ad hoc*. Checks are applied progressively and consistently. The adoption of ISO 9001 will make the process even more systematic.

SAIME has had no formal education or training in risk management, nor has any other member of his staff. He has 18 years of experience, mainly in fire protection engineering, with ten years in a consultancy role - the last two as a director of the firm.

The consultancy does not maintain any explicit risk register, but the operations manual acts as a systems checklist in terms of information requirements.

No computerised risk analysis is carried out. SAIME noted that airconditioning is often more of an "art than a science". Fire engineering and electrical load calculations are done on a computer, but not explicitly as risk analysis processes.

Referring to the social risk of substance abuse occurring on site, SAIME noted that he could recall only one site where warning notices were posted for employees to see, yet he believed that drug-taking was prevalent on most sites and suggested that productivity would probably suffer if it was prohibited.

He noted that, in periods of fluctuating exchange rates, contractors and subcontractors were advised to obtain forward cover for the cost of major imported components.

His firm tries to monitor inflation by keeping a cost database of previous projects and identifying trends from this.

SAIME believes he has an intuitive feeling for risks, based upon experience.

SAIME considers himself to be moderately risk seeking, both professionally and personally. He thinks that the client is likely to be risk averse while the other project stakeholders are all likely to be professionally risk seeking. He has no knowledge of their personal risk attitudes.

Main Contractor

At the time of interviews, no main contractor had been appointed for the project.

8.3.3. Intra-project comment

Project riskiness.

Table 8.5 depicts the tabulated responses of stakeholder interviewees to the criteria intended to establish the “riskiness” of the SA1 computer centre case study project.

The different views of stakeholders about the time, cost and quality objectives of the project would be unlikely to substantially increase its level of risk. These differences are more likely to result in minor conflicts between stakeholders as the project proceeds, particularly if quality has to be sacrificed to cost at some point.

The completion time required for the project is generally considered to be severe (rather than extreme) by interviewees. One interviewee commented that late completion of the project would not be disastrous, as the teaching spaces were primarily intended for student self-paced learning and unstructured tutorials rather than for scheduled lectures.

The completion time risk will be mitigated by the inclusion of liquidated damages clauses in the contract agreement.

While the joint venture consultancy arrangements mitigate the risk of lack of consultant experience, they do increase the risk of inter-stakeholder communication failure.

Risk criteria	Project manager (SA1PM)	JV Architect (SA1A)	Quantity surveyor (SA1QS)	Structural engineer (SA1SE)	JV Mech/Elec. Engineer (SA1ME)
Client business sensitive to project quality, cost or time?	Time. Cost. Quality.	Time.	Cost. Quality. Time.	Quality.	Cost.
New technology or development of existing technology required?	Tensile roof.	No.	No.	No.	No.
Novel methods required?	No.	No.	No.	No.	No.
Large or complex project?	Average.	Large size. Average complexity.	Average size. Simple.	Average size. Simple.	Average size. Simple.
Extreme time constraint?	Severe.	Severe.	Severe.	Severe.	Critical.
Stakeholders experienced?	Yes.	Yes. (NB. Joint Venture)	Yes.	Yes.	Yes. (NB. Joint Venture)
Project subject to regulatory changes?	No.	No.	No.	No.	No.
Project in a developing country?	Yes (but developed economy).	Yes (but developed economy).	Yes (but developed economy).	Yes (but developed economy).	Yes (but developed economy).

Table 8.5. Case SA1: Stakeholder perceptions of project “riskiness” criteria.

Compared to the African continent as a whole, the current political environment in South Africa may be described as stable. The industrial relations climate, however, remains sensitive, with industry employers apprehensive about the impact of new labour laws upon costs and foreign investment (BIFSA, 2000). According to the same BIFSA report, the South African construction industry was beginning to show signs of slow recovery from the weakened situation which prevailed in 1998 and 1999. There are no abnormal economic factors, therefore, which could affect the riskiness of Project SA1; nor were stakeholder interviewees aware of any unusual environmental constraints for the site.

Generally, the criteria responses suggest that this cannot be regarded as a high risk project.

Project and stakeholder risk management.

Table 8.6 depicts the summarised responses of the case study participants’ responses to interview questions relating to the project and their organisational risk management practices.

Risk management practice aspect	Project SAI	Project manager (SA1PM)	JV Architect (SA1A)	Quantity surveyor (SA1QS)	Structural engineer (SA1SE)	JV Mech/Elec. Engineer (SA1ME)
Formal risk management system in place?	No. <i>Ad hoc</i> approach used.	No. <i>Ad hoc</i> approach used.	No. <i>Ad hoc</i> approach used. Weekly staff review of projects, plus mini-reviews as required.	No, but cost planning procedures provide a system. Weekly staff seminars.	No. <i>Ad hoc</i> approach used. Weekly project reviews (outcomes recorded).	No, but operating manual is systematic. Project design concepts and budgets reviewed by non-involved staff.
Risk identification processes?	Not explicit. No risk register.	Not explicit. No risk register. Focus upon critical project success factors.	Not explicit. No risk register. Review process used.	Not explicit. No risk register. Elemental cost plan used.	Not explicit. No risk register. Review process used.	Not explicit. No risk register. Review process used.
Risk analysis processes?	No formal or mathematical processes used.	No formal or mathematical processes used.	No formal or mathematical processes used. Review process used.	Computerised elemental cost planning used.	Review process used. Computerised structural design.	Review process used. Computerised design calculations.
Responsibility for risk response decisions?	Each stakeholder makes own decisions.	Head of department.	Directors.	Associate partner.	Office manager.	Office director.
Risk monitoring and control processes?	Project team meetings.	Focus on critical project success factors.	Review processes (no formal records).	Project cost administration processes.	Review processes.	Review processes.

Table 8.6. Case SA1: Project and stakeholder risk management practices.

Risk management practice aspect	Project S1	Project manager (SIPM)	JV Architect (SA1A)	Quantity surveyor (SIQS1 & 2)	Structural engineer (SA1SE)	JV Mech/Elec. Engineer (SA1ME)
Possible improvement to risk management practice?	Not applicable.	Implement more formal system.	Use more formal decision-making processes.	Adopt ISO 9001.	Adoption of ISO 9001 under consideration	Implementation of ISO 9001 underway.
Barriers to implementing more systematic risk management processes?	Not applicable.	Time to implement.	Administrative effort needed.	Co-operation needed between stakeholders.	Logistics (not cost).	Review and revise operational manual.
Post-contract risk de-briefing process?	Not known but unlikely.	No. Cost reconciliation only.	Informal review by project team.	Cost reconciliation only.	Informal internal review (issues recorded).	Client feedback sought. Issues noted at monthly "mechanical" meetings.
Risk communication media?	Contract agreement. Meeting minutes. Letters, faxes and telephone.	Meeting minutes. Letters, faxes, telephone and e-mail.	Meeting minutes. Letters, faxes, telephone and e-mail.	Meeting minutes. Letters, faxes, telephone. Direct report to client on all cost matters.	Meeting minutes. Letters, faxes, telephone and e-mail.	Meeting minutes. Letters, faxes, telephone and e-mail.

Table 8.6. (Contd.) Case SA1: Project and stakeholder risk management practices.

None of the stakeholders interviewed has any formal education or training in risk management, and all rely on their experience and intuition to deal with project risks.

No formal, explicit, systematic process of risk management is used on this project. Nor do any of the interviewed project stakeholders exercise formal risk management practices. Instead, *ad hoc* or substitute processes are used. Most of the consultants use regular internal staff or project team meetings or seminars to review and brainstorm project issues, but practice (ie. company) issues are dealt with more sporadically on a case by case basis at senior management/director level.

None of the interviewed project stakeholders maintains a formal risk register.

The project manager's risk identification focus is upon critical time, cost and quality success factors for each project. The architectural joint venture consultancy uses internal project team mini-reviews, and full staff reviews, to identify risk-related issues. For the quantity surveyor, project cost is a critical factor, and the elemental cost planning process provides an adequate risk checklist. The structural engineering consultant relies on the experience of its project team leader, and the review process, to highlight risks. The mechanical and electrical engineering joint venture consultancy uses a similar process, aided by its operational manual. None of the interviewees described their procedures explicitly as risk identification, but saw them as prudent professional practice.

No formal, explicit risk analysis processes have been used on Project SA1. The quantity surveyor's cost planning processes are spreadsheet-based, using simple "what if?" replacement of cost data to explore alternatives. The engineering consultants each use computerised systems for design calculation, but without transparency of any probabilistic data treatment.

For Project SA1, each stakeholder makes his own risk-related decisions with little or no reference to the other stakeholders. The project manager makes these decisions under the direction of his head of department. For the other interviewees, this decision-making generally occurs at the strategic apex of the organisation (Mintzberg, 1979), at senior management or director level.

Implicit monitoring and control of project risks (and specifically time and cost-related risks) occurs at project team meetings for Project SA1. Within their own organisations, interviewees tend to use regular review meetings and seminars for this purpose. There is no evidence, however, to show that any risk (other than overall project cost) is systematically tracked and controlled, by any of the consultants, throughout their period of involvement with a project.

The project manager suggested that his organisation needs to improve its risk management by adopting a more formal system; while the architect thinks his practice should formalise its currently informal decision making processes. The other consultants believe that the implementation of ISO 9001 would substantially improve their risk management practice by minimising the chance of incidents giving rise to professional liability.

Suggested barriers to implementing more systematic risk management processes included: the lead time to implement a system; the additional administrative effort required; and the actual logistics of implementation.

Within their own organisations, the interviewees involved in design matters limit their post-project de-briefing processes to informal reviews. The structural engineering consultant notes that the outcomes of these meetings are recorded. The mechanical and electrical engineers, as part of their operating procedures, also ask for client feedback on the quality of their services, and technical aspects of the completed project might be raised at their monthly “mechanical” meetings. For the quantity surveyors, post-contract debriefing was limited to cost reconciliation, as an integral part of their client service.

The contract agreement was the most explicit risk communication medium identified by interviewees on Project SA1. Minutes of meetings were thought to be the next most explicit means, followed by letters, faxes and (at a much lower level) telephone calls and e-mail messages.

The findings about risk management practice to be drawn from the interviews with Project SA1 stakeholders are that:

- Neither the project, nor any of its stakeholders, has adopted formal and systematic risk management processes.
- Risk identification processes are limited mainly to design review meetings, and are not explicit.
- Little or no project or stakeholder organisational risk analysis is carried out. Very limited amounts of (implicit) project risk analysis occurs through the computerised processes used by some consultants.
- A limited amount of risk monitoring and control takes place on the project (through project team meetings) and in the stakeholder organisations (through staff meetings).
- Little risk de-briefing occurs after projects have been completed.
- Stakeholders are not familiar with the processes of formal risk management, and are concerned about the effort and resources needed to implement them, despite appreciating the potential benefits of such systems.
- Shared understanding of project risks is assumed to be achieved largely through the formal contract agreement.

Implications of organisational structure.

The organisational structures identified within case study Project SA1 comprise:

- Project: temporary, administratively-ordered, simply structured professional bureaucracy.
- Project manager/client: administratively-ordered professional bureaucracy.
- Architectural joint venture: administratively-ordered, simply-structured professional bureaucracy (JV1); combined with simple structure (JV2).
- Quantity surveyor: administratively-ordered divisionalised professional bureaucracy.
- Structural engineer: administratively-ordered professional bureaucracy.
- Mechanical and electrical engineering joint venture: combined administratively-ordered simply structured professional bureaucracies (JV1 and JV2).

The simply-structured nature of most of these organisations, together with their localised decision-making, will assist in the communication process. The quantity surveyor has (as in the case of Project S1) avoided the communication disadvantages of a divisionalised organisational structure by using small divisions (project teams) with short communication paths to relevant decision-makers.

The project and stakeholder organisations are all administratively ordered, as in Project S1.

Within the architectural consultancy, the JV1 firm has an architect director as the senior director, but the other architectural directors will all play a role in every project, and are thus interchangeable to some extent. This also applies to projects undertaken through the planning discipline of the JV1 firm. The simple administratively-ordered organisational structure is therefore somewhat loose but, because of its professional cadres, still more closely resembles a professional bureaucracy than an operating adhocracy. The result is really a compromise between administrative efficiency and innovative outputs – a situation with the potential to give rise to internal conflict within the organisation. The sharing of authority between three directors on this project may also cause communication (and hence decision-making) difficulties for the JV2 partner and other project stakeholders. There is less danger of this within the mechanical and electrical engineering joint venture consultancy, since both partners operate from the same building (also shared with the JV1 architects) and have arisen from the same original firm.

Other project stakeholders are seemingly unaware of the hidden managerial risks this situation poses, since none knew which of the joint venture partners constituted their principal contact point.

Risk profiling.

The interviewees' perceptions of their own risk profiles (professional and personal) are shown in Table 8.7.

Risk Profile	Project manager (SA1PM)	JV Architect (SA1A)	Quantity surveyor (SA1QS)	Structural engineer (SAISE)	JV Mech/Elec. Engineer (SA1ME)
Professional risk profile.	Risk averse	Risk averse.	Risk averse.	Risk seeking.	Risk seeking.
Personal risk profile.	Increasingly risk averse	Risk averse.	Risk averse.	Risk seeking.	Risk seeking.

Table 8.7. Case SA1: Stakeholder perceptions of their own risk profiles.

The structural engineering consultant, and mechanical and electrical engineering joint venture consultants, saw themselves as professionally risk seeking in a commercial sense, in that they were competing, in an increasingly competitive environment, for work. This, they thought forced them out of their more normal risk averse design professionalism.

Table 8.8, read horizontally across each row, displays interviewees' perceptions of the professional risk profiles of other project stakeholders.

The project manager saw the architects as being risk seeking largely on the basis of the tensile membrane design proposed for the atrium roof. The architects (SA1A), however, had noted in their interview that they would only be prepared to be risk seeking on fully informed basis, and that tensile membrane roofs were well-known and no longer considered innovative in the design world.

The quantity surveyor's (SA1QS) preoccupation with financial and economic risks tended to influence his assessment of the professional risk profiles of other stakeholders, causing him to assume that he was bearing the project cost risk and that the other stakeholders had little to be concerned about.

The mechanical and electrical engineering joint venture partner (SA1ME) assumed that his risk-seeking approach to obtaining work was prevalent among the other stakeholders.

None of the interviewees was prepared to offer an opinion of the personal risk profiles of others.

Stakeholder:	Project manager (SA1PM)	JV Architect (SA1A)	Quantity surveyor (SA1QS)	Structural engineer (SA1SE)	JV Mech/Elec. Engineer (SA1ME)
Project manager (SA1PM)	☺	Risk seeking	Risk averse.	Risk averse.	Risk averse.
JV Architect (SA1A)	Risk averse.	☺	Risk averse.	Risk averse.	Risk averse.
Quantity surveyor (SA1QS)	Risk neutral.	Risk neutral.	☺	Risk neutral.	Risk neutral.
Structural engineer (SA1SE)	Risk averse.	Risk averse.	Risk averse.	☺	Risk averse.
JV Mech/Elec. Engineer (SA1ME)	Risk seeking.	Risk seeking.	Risk seeking.	Risk seeking.	☺

Table 8.8. Case SA1: Stakeholder perceptions of other stakeholders' professional risk profiles.

These findings add little more to those from Project S1, except to suggest that perceptions of the risk profile of other stakeholders may be influenced by the current preoccupations of the perceiver. The findings also add weight to the notion that personal risk profiles are largely unrelated to, and do not impact upon, professional risk profiles.

Risk “stories”.

Accounts of previous risk “experiences” were given by the quantity surveyor (SA1QS), the structural engineer (SA1SE), and the mechanical and electrical engineer (SA1ME). With the exception of the structural engineer’s story, however, all related to potential, rather than actual risk events, in that pre-emptive corrective action had been taken. The project manager (SA1PM) and architect (SA1A) could not recall any risk events.

The risk event described by the structural engineer (SA1SE) is interesting in that it covered an incident requiring human resource management and industrial relations skills on a project where his company was acting as project manager (as distinct from its engineering consultancy role).

The interviewee's intervention was occasioned more by his ethnic background than by his HRM and IR skills, and arose largely out of the contractor's unfamiliarity with organised industrial action – a legacy from the previous government regime where such action had been illegal.

The paucity of risk stories will be discussed under the inter-project analysis later in this Chapter.

8.4. South African Case Study SA2

8.4.1. Project description and organisational structure

The second South African case study is a proposed new office building for a private client. The new building forms the second phase of an office park development at Milnerton, a suburb of Cape Town. The objective for the project is to develop a commercially viable short term investment asset. The clients is a development consortium comprising a property development company, a national bank, and a project management company.

The estimated cost of the project is ZAR5.1 million, including an allowance for office partitioning but excluding 14% VAT and all professional fees.

The procurement system for the project is a conventional separated design, tender, construct system, but the tender is being negotiated with a construction company linked to one of the client consortium companies (the property development company). Should these negotiations fail, the project will go to open tender. The project organisational structure, as indicated in Fig. 8.11, is a temporary, administratively-ordered, simply-structured professional bureaucracy.

The project management company shown as part of the client consortium also acted as consulting project managers for the Phase 1 development project. On Phase 2, they acted as project managers only for the initial planning stage, and the architects were subsequently appointed as lead consultants.

The mechanical engineering services sub-contract has been negotiated with the selected sub-contractor who carried out this work on the Phase 1 project. The Phase 1 electrical engineering services sub-contractor declined a similar negotiation for Phase 2, but has subsequently won the selected sub-contract through open tender.

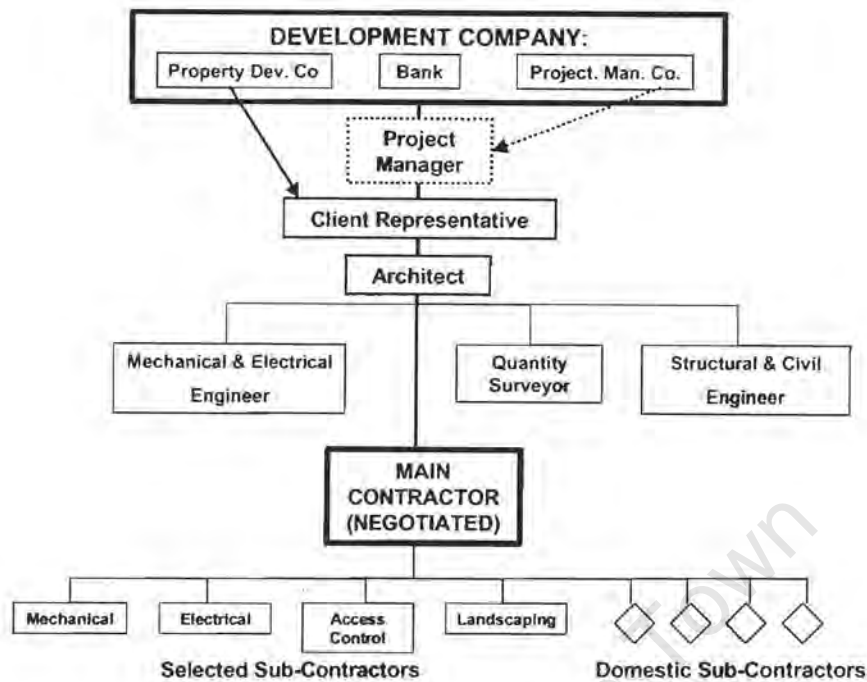


Fig. 8.11. Case SA2: Project organisational structure.

The proposed building has a gross floor area of 2267 m² (including 847 m² basement parking) and comprises two floors above the semi-basement parking floor. The Net Rentable Area is 1296 m².

The building has a conventional flat slab and beam reinforced concrete structure founded on precast driven piles. The external envelope comprises brick walls with plaster and textured finish, and aluminium windows. Lightweight partitioning is used internally except for the service core. The contract allowance for the partitioning is based upon 25 m length of partition per 100 m² of lettable floor area, and tenants will pay for any additional partitioning they require.

A pipeline servitude, 9.5 m wide, owned by a major oil and gas utility company, runs across the site.

Interviews were conducted with project stakeholders during September, 2000.

8.4.2. Interview summaries

Client Representative

The client representative was interviewed in his suburban office. The interview lasted one and a half hours.

SA2CR is the client representative for the client consortium company (which has a simple structure whereby appointed representatives of the three consorting companies meet together; report upwards to their respective parent organisations and downwards through SA2CR), and has signing power on behalf of the consortium. He is an area director for a large development company, which is part of a national group of 30 companies in Southern Africa, with construction-related business activities spread over several divisions including: property development, building, roads, civil engineering, manufacturing, water and sanitation services, and infrastructural developments.

SA2CR has a bachelor of engineering honours degree and a bachelor of commerce honours degree.

The client's objective for the project is to carry out a short term speculative development for sale, generally with tenants secured.

SA2CR filled in some of the background to the whole development project. His development company replaced another company in the consortium, whose original idea was to undertake a single large development on the site. Feasibility studies by the architect and quantity surveyor indicated that this was a high risk approach, although total development costs might be lower, as this approach would produce a property too big for the current market to "swallow in one bite". In addition, market research showed that the site location (close to the beach) and general ambiance of the area would be more attractive to both potential buyers and tenants if the development was released onto the market in smaller parcels. The current marketing approach for the project reflects these findings. The sales/leasing brochure for the property uses the slogan "Getting to work has never been easier" and the front cover shows a business-suited executive riding a jet-ski across deep blue water. Inside, the brochure emphasises (graphically and in the text) the beachfront location and views of Table Mountain, as well as proximity to the city centre, industrial areas, major regional shopping centres and Cape Town International Airport - all within the circumference of a circle of less than 15 kilometres radius. The only drawback is that there are no retail facilities currently near to the development site for the day-to-day shopping needs of

occupants, but nearby land is zoned for commercial/retail development, so it is likely that the office park will act as the trigger for such development. The brochure also states the names of the three partner companies, as it was considered that each provided a status value to the project in terms of their core activity, expertise and business reputation.

Each phase is intended to provide lettable office space available in flexible combinations of 300m² floors. A single client can take floor areas from 300 to 1200 m² in low rise buildings with basement and open parking and controlled access. Phase 1 is fully let and one of the tenants is negotiating to buy the building. Leasing interest has already been shown in Phase 2. The whole site development is anticipated to cost R40 million. Letting is on the basis of five-year leases with 12% annual escalation in rent. The selling price for Phase 1 is about R8 million, and it is anticipated that the price for Phase 2 will be about R9 million. SA2CR noted that, despite some customer interest, he is not prepared at this stage to offer space under 300 m² to single tenants, but will wait to see if larger tenancies can be secured. In his view, larger tenants tend to agree to longer leases.

In SA2CR's opinion, the project outcome is equally sensitive to time, cost and quality. Phase 2 is small and simple, and presents a relatively low risk undertaking for the client company.

The completion deadline for the project is manageable, particularly as Phase 1 acts as a good model for the contractor, which is the same firm on both phases.

SA2CR considers the other project stakeholders to be adequately experienced. He noted that the consultants are those who had been appointed for the previous scheme, before the entry of his development company. He has not worked with any of them before, but other companies in his parent group have dealt with them extensively on other projects.

The client company itself does not undertake any formal processes of risk management, and keeps no check lists. However, this is largely due to the temporary nature of the client consortium. Each of the partner companies undertakes levels of risk analysis appropriate for its core business activities, and brings this expertise to the client company. The bank has financial risk analysis skills; the developer has expertise in site analysis and marketing; while the project management company has skills in planning and controlling projects.

In SA2CR's view, the client consortium is risk averse. He noted that the project management company used a simple formula, based upon percentage allowances of the estimated costs of each

of the design elements in the project cost plan, to build up a contingency amount for the project. This would be reduced (or expended if necessary) as each element was completed on site. At an appropriate point during construction, any balance would be transferred to a management reserve (i.e. not left to the consultants' discretion) and used for marketing and promoting the property or for upgrading features such as landscaping and decor.

The "early warning system" used on this project in project site meeting minutes has proved to be a valuable management tool to reveal potential problems. SA2CR noted that he tries to impress upon consultants that, as the client, his priority is to be informed about issues in time to explore remedial action, rather than to apportion blame when it is too late.

No formal post-project risk decision analysis is carried out. Project debriefing with the consultants was carried out on Phase 1 as it provided key information for improving Phase 2. This information augmented that provided in the "project base-line" document, prepared by the project management partner company. This document appears to act as a comprehensive client brief.

SA2CR believes that making the project "baseline" document even more comprehensive would improve the client's decision-making processes. In his opinion, while the risk management process on the project has not been explicit and formal, it has been systematic. He noted that, for his own company, this is particularly true on most projects after the site has been acquired. Prior to land acquisition, risk management is usually *ad hoc*.

SA2CR has had no formal education or training in risk management, but his undergraduate degrees included aspects of engineering and financial risk analysis.

Specific computerised risk analysis models were not used on this project, but spreadsheets were used for the feasibility studies and these included "what if" scenarios and sensitivity analyses.

SA2CR thinks he has an intuitive feeling for risks, based upon his experience.

He considers himself to be professionally risk averse. In his personal life he thinks he is also risk averse, although a moderate risk seeker in terms of leisure activity (he has done para-gliding) when he is fully informed about, and trained to respond to, the risks involved.

He believes that the structural engineering consultant and the quantity surveyor for the project are professionally risk averse; but that the mechanical and electrical engineering consultant and the

senior partner of the architectural consultancy are moderately risk seeking. He suggested that the contractor's estimator might be risk seeking, but that the construction management team will be risk averse.

SA2CR identified several risk events from the catalogue. Heavy flooding of a nearby river had occurred on a previous project, but the deliberate flood design precautions has been successful as the maximum flood height had occurred about 50 mm below the lowest floor level.

He noted that the pending introduction of capital gains tax on second properties could have a substantial impact on all sectors of the property market, including developments such as office park, where small companies buying a block as an investment might subsequently be liable for the tax upon resale. Rises in interest rates, above forecast levels, are less of a risk in South Africa than might be expected, as a small increase in high levels of rates (e.g. a 1 percentage point rise to a 15% rate) will have less impact than the same rise in a low rate (e.g. a 1 percentage point rise to a 5% rate). Inadequate cost control systems can be a major risk for a developer on any type of development, but particularly on residential projects where units are sold to many individual buyers and recovery of additional (authorised) costs is often difficult.

Project Manager

The project manager for the office park project participated only in the preliminary planning stages of Phase 2 of the office park development. As the person concerned was based in Johannesburg, he was not available for interview. His role in the project was taken by the architect, who was appointed as the lead consultant for Phase 2.

Architect

The architect (SA2A) for the office building project was interviewed in his city office in Cape Town. The interview lasted one and a half hours.

The architects are the principal consultants for the project and are responsible for the design, design co-ordination, and contract supervision. The organisational structure of the practice is shown in Fig. 8.12. It resembles an administratively-ordered simple structure. The company was established in 1972 and has operated in its present form as a single office in Cape Town since 1983. The three partners are all registered architects.

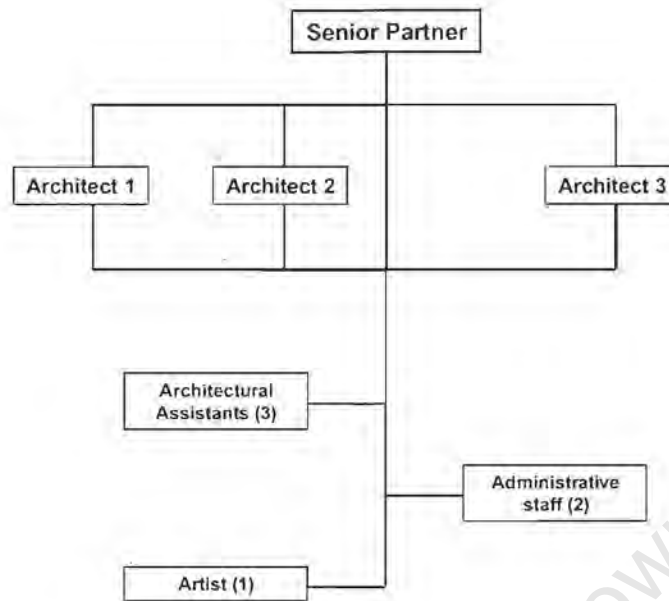


Fig. 8.12. Case SA2: Organisational structure for architectural consultant.

SA2A believes that the project objective is to make money for the clients. The large site originally attracted ideas of a single, matching large development, for its original developers. However, the feasibility study showed this was a high risk concept, as there was no other office park development in the vicinity to gauge demand. Subsequently, a new development company was formed to examine the feasibility of a phased development, incorporating separate land titles, following the architect's suggestion that this suited the linear nature of the site. The success of Phase 1 proved the soundness of this approach, comprising smaller, parcel type, development. The parking, pipe servitude and access points are on a separate title from the office parcels. The concept also matches the marketing information that office floor areas of about 300 m² would be most attractive to potential tenants, and that small, two storey buildings would be individually attractive to potential buyers. Each phase is intended to be about the same size and configuration, comprising two rectangular blocks, each with about 450 m² of semi-basement and 700 m² of offices on two upper floors. For the architects, the whole development is a "dream" project in terms of its simplicity and repetition.

In SA2A's opinion, the project outcome is equally sensitive to cost and quality, and after that for time. Compared to other building projects undertaken by his company, it is small in size and simple in complexity. No new technology is required, and no regulatory changes are anticipated.

The completion deadline for the project is severe, but manageable. The contract allows 7 months, and this still applies, even though the contractor (in negotiation) indicated that five and a half months was possible. A clause in the agreement states that no claims for weather delays will be considered.

SA2A considers the other project stakeholders to be adequately experienced. He has worked satisfactorily with the engineering services consultant and with the contractor before.

SA2A believes that design error and failure of the building to be fit for the client's purpose are the main risks that the architectural consultancy faces. These are not dealt with through a formal risk management process, but on every project the initial concepts are tested for viability, albeit with minimal staff input (SA2A noted that the more work one put in for a client, the more reward one should be entitled to - he was referring to situations where architects are expected to provide conceptual designs without fee to potential clients). The conceptual ideas are discussed with the client and, if approved by the senior partner, the firm will agree to take the project on and negotiate the fee with the client. SA2A stated that for commercial projects, the quantity surveyor's input to this process is critical, so that a good architect/quantity surveyor relationship is essential. SA2A generally writes brief specification notes on the sketch design drawings, as a base for the quantity surveyor to prepare cost plans and financial feasibility studies. On all projects, the site constraints are first identified and examined, as a key into the preliminary conceptual designs.

The project leader is responsible for checking all outgoing documentation. The "early warning system" used on this project in project site meeting minutes to flag potential future issues and problems on projects was initiated by the Phase 1 project manager, and the architects have since adopted this as standard practice on all projects.

No formal post-project risk decision analysis is carried out. Post-mortems are carried out on most, but not all, projects after completion, and usually only at the request of the client. Debriefing with other consultants was carried out on Phase 1 as it provided key information for Phase 2. One decision arising from this was to increase the size of the windows slightly on Phase 2. The consultancy does not maintain any explicit risk register.

The building quality was not high on Phase 1 and steps have been taken on this project to tighten the specification and increase the frequency of onsite inspection. It is planned to hold a formal inspection immediately before each site meeting. While the negotiated contractor for Phase 2 is

the same company which built Phase 1, its site management team will be different, and the contractor is aware that improved quality will be expected.

SA2A has had no formal education or training in risk management. After some hesitation he suggested that risk management on this project could be described as informal but moderately systematic.

Computerised risk analysis models are not used in the practice as they are not considered necessary for architectural design work.

SA2A does not believe he has a strong intuitive feeling for risks, but his experience is a valuable tool for anticipating them.

SA2A considers himself to be professionally risk averse, depending on the type of project and level of information available. On the other hand, he thinks that overall the practice tends to be risk seeking.

Personally he thinks he is risk neutral and perhaps a moderate risk seeker in terms of leisure activity (deep sea game fishing) but only where he is fully informed of the risk involved.

He believes that the other project stakeholders are all professionally risk averse, but has no knowledge of the personal risk attitudes of the other stakeholders.

SA2A identified several risk events from the catalogue. Most of these (flooding, theft, drug abuse and strike action on site) had been the responsibility of the contractor through contractual transfer and no prior risk management action appeared to have been taken. Human resource management risks in the architectural practice are basically addressed by a "get the job done first" approach, and his own planned Easter holiday this year fell victim to this priority.

Quantity Surveyor

An associate (SA2QS) of the quantity surveying consultant was interviewed in his city office. He is the firm's team leader for the project. The interview lasted one and three quarter hours.

The quantity surveyors are responsible for the preparation of the financial feasibility study, and for cost planning and contract cost administration on the project.

The organisational structure of the company is shown in Fig. 8.13. It is an administratively-ordered divisionalised professional bureaucracy. The company is well established (it was originally founded in 1922) and has fifteen offices throughout South Africa, including three in Western Cape. There is also a national corporate office in Johannesburg. The firm has recently joined an international professional quantity surveying conglomerate (the same as that associated with the quantity surveying consultant on the Singapore case study project), and has established an additional office in Johannesburg to service this association. SA2QS has a university degree in quantity surveying and is a registered quantity surveyor.

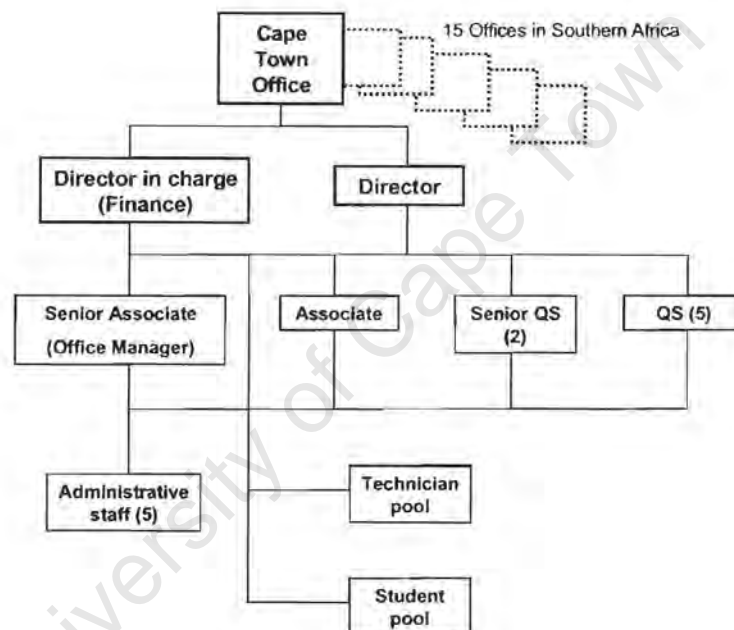


Fig. 8.13. Case SA2: Organisational structure for quantity surveying consultant.

In SA2QS's opinion, the project outcome is equally sensitive to time, cost and quality (fitness for purpose). Compared to other building projects undertaken by his company it is small in size and simple in complexity. No new technology is required, and no regulatory changes are anticipated. A clause in the contract agreement states that all authority approvals must be obtained before construction commences.

He noted that particular care has been taken with regard to the pipe servitude on the project. The utility company was asked to indicate the precise route of pipes across the property. Exploratory excavations have confirmed their location in key places, and the contract documentation contains

warnings to the contractor to avoid excavations and other intrusions within the designated lines of the servitude on the site. The pipelines are an essential part of the oil and gas delivery infrastructure for Cape Town.

The completion deadline for the project is severe, as the client does not want to delay any tenant occupancy and the development is intended to be sold on as soon as possible after completion. Negotiation with the main contractor was undertaken on the basis of the design drawings and full bills of quantities.

SA2QS considers the other project stakeholders to be adequately experienced. He has worked satisfactorily with all of them before.

SA2QS believes that estimating error is the primary risk that the QS consultancy faces. This is not dealt with through a formal risk management process, but the volume of work undertaken by the practice ensures that it maintains access to current cost data through the item prices rates submitted by the successful tenderers.

On every project the initial estimates, feasibility studies are made by the project leader and his/her team. These are discussed with and approved by the relevant director. The project leader is responsible for checking all outgoing documentation. Only persons named on the company letter head can sign outgoing documents, and a fax transmittal approval process is in place. The firm is currently considering processes for authenticating email messages.

The "early warning system", used on this project in project site meeting minutes to flag potential future issues and problems on projects, encourages timely and appropriate decision-making.

No formal post-project risk decision analysis is carried out on projects. Informal post-mortems are carried out on some, but not all, projects after completion, and usually only at the request of the client. The consultancy does not maintain any explicit risk register, but project files contain the historical details of any risk events.

Quality assurance certification under ISO 9001 is currently under way by the company, with initial system testing scheduled for October 2000.

On this project, Phase 1 was used as a risk learning model. A risk contingency distribution for this project has been made by the quantity surveyors, based upon percentage allowances to the

elemental costs calculated in the cost plan. SA2QS therefore believes that the risk management process on this project has been reasonably systematic, using empirical models.

SA2QS has had no formal education or training in risk management.

Computerised risk analysis models are not used. SA2QS is reluctant to employ mathematical approaches to risk, as in his opinion it is better to assess risk through experience. This, plus initial query lists and available time are the ingredients he uses to identify risks on projects. Risk identification is the responsibility of the project leader. Whenever possible, weekly (Monday) staff meetings are used to raise and discuss project progress, issues and problems.

SA2QS believes he has an intuitive feeling for risks, based upon his experience. On this project, having settled the final account for the Phase 1 project a week after its completion, he was able to suggest reducing the design contingency allowance for Phase 2 from 5% to 3%.

SA2QS considers himself to be professionally risk averse, depending on the type of project and level of information available. Personally he thinks he is risk neutral and perhaps a moderate risk seeker. He believes that the other project stakeholders are all professionally risk averse, except for the contractor whom he thinks is risk seeking. The latter, in negotiation, had actually indicated a possible saving of one and a half months in the construction period, but then declined to agree to liquidated damages delay clauses in the agreement being based upon a reduced time period.

SA2QS has no knowledge of the personal risk attitudes of the other stakeholders.

He identified several risk events from the catalogue. Most of these (site vandalism and theft, drug abuse on site, strike action, poor productivity) had been the responsibility of the contractor through contractual transfer. He noted that pre-purchasing was advised to the client whenever exchange rate risks were considered likely. Human resource management risks within the practice are reduced by the existence of the three Western Cape offices. This provides low/medium level staff backup where necessary, and systems between the offices are standardised, making transfer of staff or work a straightforward matter. The firm tries to keep higher level staff happy through salary reward and by giving them substantial responsibility and decision-making powers. For example, he is consulted about taking on projects and his estimates of workload and availability are used to inform clients about milestone dates. SA2QS noted, however, that three senior staff, including a director, had recently left his branch of the firm to set up their own practice.

Structural Engineer

The structural engineering consultant (SA2SE) was interviewed in his Cape Town office. The interview lasted one and half hours. The consultancy is responsible for the structural design of the building and some civil engineering design on the parking area. SA2SE is a qualified civil and structural engineer. The organisational structure of the company is shown in Fig. 8.14. It is an administratively-ordered divisionalised professional bureaucracy.

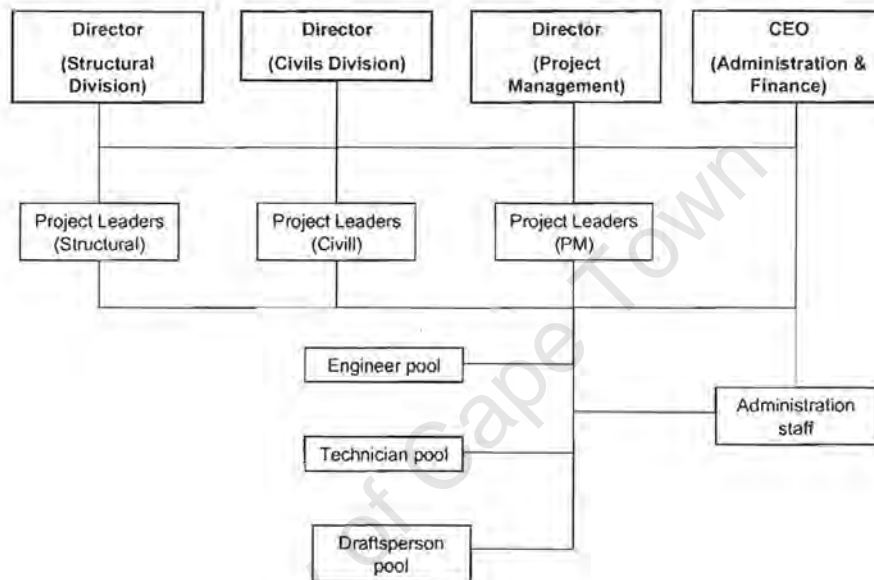


Fig. 8.14. Case SA2: Organisational structure for structural and civil engineering consultant.

The company is well established and has offices throughout South Africa. It has won numerous design awards for major structural and civil engineering projects in Southern Africa over the past forty years, and has undertaken work internationally. The Cape Town office is located in the company's own building in the city's business centre. The office is structured around three major divisions (structural, civil engineering, and project management), each under the control of a director, together with an administrative and finance division under the control of the chief executive officer. Projects are the operational responsibility of project leaders, who report to the relevant director. Project leaders consult with their directors to select project teams from the pool of engineers, technicians and draftspeople available.

In SA2SE's opinion, the project outcome is most sensitive to quality (fitness for purpose). Compared to other building projects undertaken by his company it is small in size and simple in complexity.

The completion deadline for the project is not considered severe. No regulatory changes are anticipated which could impact on the project.

SA2SE considers the other project stakeholders to be adequately experienced. He has worked satisfactorily with the mechanical and electrical engineers before.

SA2SE believes that design failure is the primary risk that the structural engineering consultancy faces. This is not dealt with through a formal risk management process, but on every project the initial design proposals made by the project leader and his/her team are subjected to independent review by other staff, and the review outcomes are formally recorded. The project leader is responsible for checking all outgoing documentation. The company uses an "early warning system" in project site meeting minutes to flag potential future issues and problems on projects. This encourages timely and appropriate decision-making.

No formal post-project risk decision analysis is carried out. Informal post-mortems are usually conducted on all projects after completion. The consultancy does not maintain any explicit risk register, but project files contain the historical details of risk events.

Quality assurance certification under ISO 9001 is currently under consideration by the company.

Where special circumstances arise (or may possibly arise) on projects, such as abnormal ground conditions, then project leaders are mandated to consult with specialists either from within the company or from outside if necessary. The review process referred to earlier acts as an implicit risk brainstorming process.

SA2SE has had no formal education or training in risk management.

Computerised structural calculations are carried out on projects, mostly employing deterministic design models according to the relevant codes.

SA2SE noted that, because of perceived deterioration in quality standards in the South African construction industry, his company had deliberately adopted a policy of increasing their on-site inspection processes, in order to reduce the risk of quality failures.

SA2SE believes his intuitive feeling for risks exists, but is not infallible.

SA2SE considers himself to be professionally risk averse and personally a moderate risk seeker. He believes that the other project stakeholders are all professionally risk averse. He has no knowledge of their personal risk attitudes.

Mechanical and Electrical Engineer

The mechanical and electrical engineering consultant for the project (SA2ME) was interviewed in his suburban office. The interview lasted one and a quarter hours.

The consultant is responsible for the electrical engineering and access control design for the project. The organisational structure of the company is shown in Fig. 8.15. It resembles a simple structure. The company was established in 1958 and, although the original partners have changed, still operates as a small single office in the Western Cape. The practice concentrates upon electrical engineering, but has an association with another firm to provide civil, structural and mechanical engineering consultancy if these services are needed. SA2ME is a qualified professional electrical engineer.

In SA2ME's opinion, the project outcome is equally sensitive to time, cost and quality. Compared to other building projects undertaken by his company it is small in size and simple in complexity. The only technologically complex aspect was designing the building to be user friendly for an IT environment. This required careful consideration of the placing of wireways for data cabling and optic fibre cable installation.

The completion deadline for the project is severe in terms of the contract agreement and the likelihood of tenants wishing to move in. No regulatory changes are anticipated which could impact on the project.

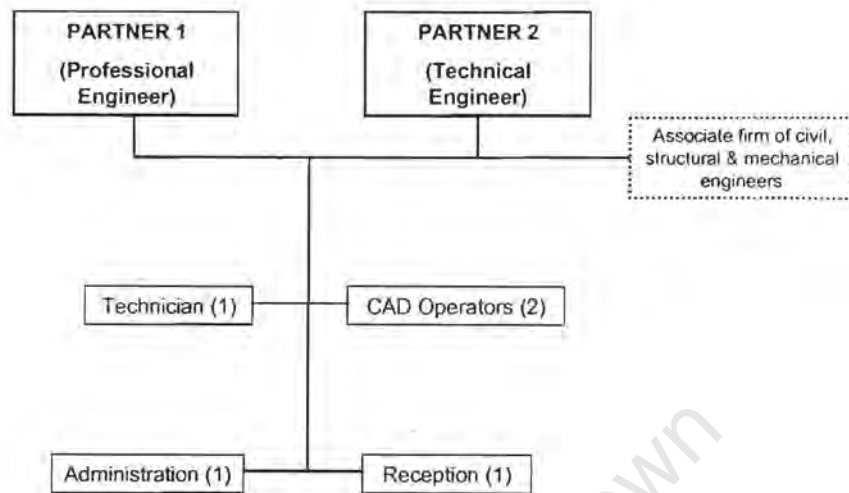


Fig. 8.15. Case SA2: Organisational structure for mechanical and electrical engineering consultant.

SA2ME considers the other project stakeholders to be adequately experienced. He has worked satisfactorily with the structural engineers and the quantity surveyors before.

SA2ME believes that design failure is the primary risk for his firm. This is not dealt with through a formal risk management process, but on every project the initial design proposals are reviewed by other staff. This acts as an implicit risk brainstorming process. The review outcomes are not formally recorded, as this is not thought necessary in a small practice. All new projects are initially examined to identify any new or unusual features, or any severe constraints, and this acts as a method of risk identification. The project leader is responsible for checking all outgoing documentation. Either partner may sign off administrative and operational correspondence, but both must sign where company finance is involved.

The company has adopted the "early warning system" used in project site meeting minutes on Phase 1 of the office park development to flag potential future issues and problems on projects. This is now used on all the firm's projects. SA2ME noted that this device proved useful on Phase 1, alerting the project team to potential delays in obtaining electrical and telephone service connections for the project, thus necessitating earlier decision-making for some key aspects of the

installation layouts. He describes the system as a "proactive and *ad hoc*" approach to risk management. He also pointed to the "baseline" document, produced by the project management company for the project, noting that this had provided a good checklist of project risks, as well as giving all the stakeholders clear guidelines for their roles.

SA2ME believes that the organisational approach to decision-making and risk in his firm has evolved over time, and that criteria for assessing the success or failure of decisions are established and implemented by the partner responsible for the project.

No formal post-project risk decision analysis is carried out. Informal post-mortems are usually conducted on all projects after completion, but the outcomes are not formally recorded. The consultancy does not maintain any explicit risk register, but project files contain the historical details of risk events as noted above. Because the firm is small, the project experiences are quickly pooled. From Phase 1 of the office park development, for example, his firm has noted the need for more corrosion-proof electrical componentry in view of the harsh coastal environment. SA2ME commented that his firm's "informal database" works well, and that a team approach, often involving all staff, is used to explore risks.

SA2ME has had no formal education or training in risk management, but his professional engineering association does arrange seminars and courses on this topic, and he has attended some of them.

Computerised risk analysis is not carried out on projects, as it is not considered necessary. The design codes are reasonably easy to interpret and comply with.

SA2ME believes he has an intuitive feeling for risks, based upon his experience. He suggested that projects where more pressure is placed upon the designers, in terms of design time, usually end up with more risk exposure for the client during construction. He prefers to work on projects where he knows the client (or at least knows the client has a good reputation), and where he has worked with at least some of the other consultants before. Unknown clients do pose the risk of security of payment of fees, but his firm does not make regular checks on the financial standing of clients, despite having come close to losing a substantial amount in fees on a recent project.

SA2ME considers himself to be professionally and personally risk averse. He believes that the other project stakeholders are all professionally risk averse. He has no knowledge of their personal risk attitudes. (NB. SA2ME appeared to confuse risk seeking and risk aversion, as he

initially chose the former description. However, his subsequent explanation clearly showed that he had actually intended to choose risk aversion).

SA2ME amplified several of the risks indicated in the catalogue shown to him. He recalled an incident involving lightning strike on a project at Atlantis, an area noted for its frequency of lightning occurrence, where several control panels had been damaged. The original design had specified the installation of protective surge arresters, so the damage was not as serious as it might have been, but the risk event did reveal the need for greater improvement in the protective design for the electrical installation.

Cable theft was a common occurrence on all projects, but this was entirely the risk of the electrical contractor. Industrial relations action tended to be ongoing in the electrical trades industries, but generally this was not serious in duration or impact. Although few incidents of materials supply shortages occurred, long delivery periods for some components (e.g. 12 - 16 weeks for some types of transformers) could, if accompanied by poor pre-planning, cause serious problems on all types of projects. SA2ME noted that the 1998 economic "melt-down" in South Africa caused havoc in interest rates and had been disastrous for many private sector commercial projects. He also pointed to deterioration in capital supply as the cause of many contractor bankruptcies.

In terms of managerial risks, SA2ME commented that a risk his firm always faced on public sector projects was delay due to late information flows from the client or from other consultants. It was difficult to mitigate this risk when fixed delivery dates were imposed and the size of the firm restricted staff flexibility. Generally, the main risks of design failure related to incorporating adequate safety factors in the system design, and allowing sufficient capacity for load growth, particularly in projects such as commercial centres, where frequent changes of tenant and changes in operating technology (e.g. e-commerce and electronic access and security) were likely.

Main Contractor

The chief estimator for the main contractor (SA2MC) was interviewed in his suburban office. The interview lasted one and a quarter hours.

The main contractor for the office park project Phase 2 is a regional division of a large national company comprising thirty subsidiary companies in Southern Africa, with construction-related business activities spread over several divisions including: property development, building, roads, civil engineering, manufacturing, water and sanitation services, and infrastructural developments.

The organisational structure of the regional construction company is shown in Fig. 8.16. It is an administratively-ordered divisionalised structure with a simply-structured local division.

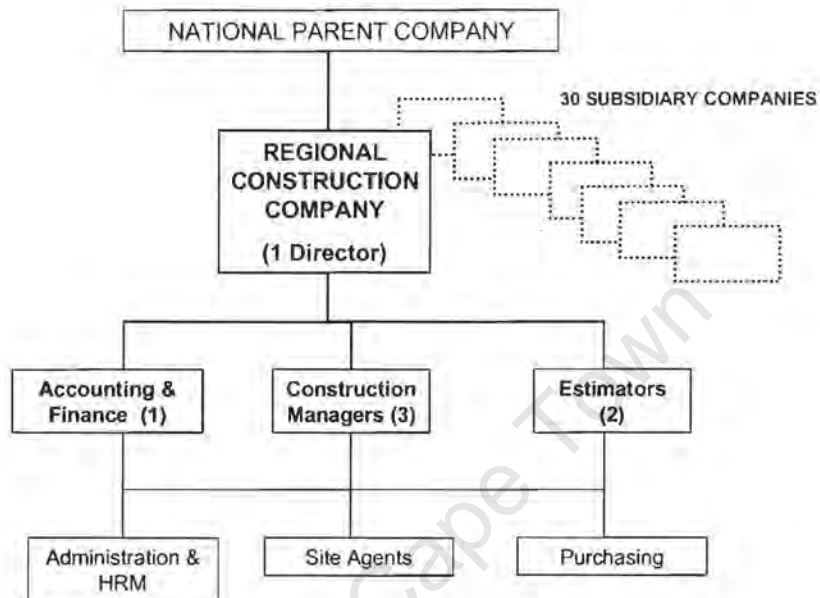


Fig. 8.16. Case SA2: Organisational structure for main contractor.

The company has negotiated the contract for Phase 2 on the basis of drawings and bills of quantities, together with its experience on Phase 1. The contract is about to be signed.

In SA2MC's opinion, the project outcome is most sensitive to cost. Phase 2 is considered small and straightforward.

The completion deadline for the project is tight, but reducing the time period was the only way the contractor could meet the cost limits imposed on Phase 2 by the client. The experience gained in Phase 1 should allow a faster completion time, and a more experienced site management team has been assembled for Phase 2.

SA2MC considers the other project stakeholders to be adequately experienced. He noted that the consultants are those who had been appointed for the previous phase. Personally, he has not worked with any of them before, but other companies in the group have dealt with them.

The construction company has recently adopted a policy of undertaking formal risk management on all projects over ZAR25 million in value. The risk management system includes the stages of risk identification, analysis and response, but does not yet appear to include a systematic process for subsequently monitoring and controlling risk. Staff are expected to "keep an eye on things".

Brainstorming, between the local director, construction managers and estimators, is used to identify risks. These are then categorised more or less according to the relevant department of operation of the company (e.g. planning, ordering and buying, site, finance). This helps to locate responsibilities. The more serious risks, selected on the basis of team opinion, are then analysed. An arbitrary scoring system (on a scale of 1 to 10) is used to assess probability and impact, and thus to rank the risks. Responses to the risks are discussed and decided, and the costs of response are estimated to give a rough and ready measure of cost/benefit.

The risk management system is quite new and staff are still learning how to use it. As more experience is gained, it will probably be used on projects of lower value. No formal post-project risk decision analysis is carried out, but informal project debriefing is undertaken with both office site staff, and notes are kept for future use.

SA2MC believes that, as staff become accustomed to the new risk management system, it will become more comprehensive and that a risk database (register) will grow quickly.

Although the Phase 2 office park project is small and far less than the ZAR25 million criterion value, he thinks that the new risk management system has encouraged staff to look at risk more systematically on this project. The company is also considering the adoption of ISO 9000 and its certification processes.

Specific computerised risk analysis models were not used on this project, but spreadsheets were used for the financial studies during negotiation. In his view, any computerised risk analysis applications should be tailored for construction. He had not heard of @Risk™ or other computer models.

SA2MC has had no formal education or training in risk management. He thinks he has an intuitive feeling for risks, based upon his experience. He considers himself to be professionally risk seeking in a positive sense of grasping suitable opportunities for company profit. In his personal life he thinks he is also a moderate risk seeker in terms of leisure activity.

He believes that the client is risk averse, given the reluctance to proceed with the project other than on a fully pre-let basis, but he was reluctant to assign professional risk profiles to the other project stakeholders, and has no knowledge of their personal risk profiles.

SA2MC identified risk events from the catalogue. He noted that, on a previous project, flooding problems had been anticipated, and de-watering systems had been employed as a risk reduction measure. Geotechnical risks are largely avoided by familiarity with the project location, or by undertaking preliminary site investigations if necessary.

Most of the economic risks are analysed at tender stage, and schedules or rates are adjusted where necessary. Legal risks in terms of adverse contract clauses are rare, and are identified quite quickly, as a standard form of contract is almost invariably used. The local Master Builders Association also keeps a watchful eye on non-standard clauses, and will bar members from submitting tenders if it considers that their interests are jeopardised. As the Association is a “closed-shop” organisation, rogue tenders are extremely unlikely. The MBA would not allow members to tender if non-members were included in a tender list.

8.4.3. Intra-project comment

Project riskiness.

Table 8.9 depicts the tabulated responses of stakeholder interviewees to the criteria intended to establish the “riskiness” of the SA2 office building case study project.

The responses suggest that Project SA2 is not a high risk project, especially given the success of its Phase 1 predecessor. Despite its speculative commercial nature, project development has been arranged so as to minimise economic and financial risks for the client. These arrangements include: deliberate structuring of the development company to maximise availability of resources and expertise; appropriate market research; the “parcelling” of the whole development; pre-selling before completion where possible; and maximising spatial flexibility but minimising small leases.

Damage occurring to the pipeline servitude is an obvious risk on this project. The client’s risk has been mitigated by obtaining as much information as possible and then transferring most of the risk contractually to the contractor.

Risk criteria	Client Rep. (SA2CR)	Architect (SA2A)	Quantity Surveyor (SA2QS)	Structural Engineer (SA2SE)	M & E Engineer (SA2ME)	Main Contractor (SA2MC)
Client business sensitive to project quality, cost or time?	Time Cost Quality	Cost Quality Time	Time Cost Quality	Quality	Time Cost Quality	Cost
New technology or development of existing technology required?	No.	No.	No.	No.	IT user-friendly requirement	No.
Novel methods required?	No.	No.	No.	No.	No.	No.
Large or complex project?	Small Simple	Small Simple	Small Simple	Small Simple	Small Simple	Small Straight-forward
Extreme time constraint?	Severe but manageable	Severe but manageable	Severe.	Manageable	Severe.	Tight.
Stakeholders experienced?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Project subject to regulatory changes?	No.	No.	No.	No.	No.	No.
Project in a developing country?	Yes (but developed economy)	Yes (but developed economy)	Yes (but developed economy)	Yes (but developed economy)	Yes (but developed economy)	Yes (but developed economy)

Table 8.9. Case SA2: Stakeholder perceptions of project “riskiness” criteria.

The economic, political and social climates for this project are similar to those for Project SA1, although it should be noted that the contract places no affirmative action empowerment requirements on the contractor as it is a private sector project. Even if anticipated legislation (to enforce the policy unilaterally) were to be accelerated, this would not constitute a large risk to the contractor which, because of its need to obtain public sector work, has already adopted affirmative empowerment measures throughout the company.

The pipeline servitude itself is subject to environmental protective measures aimed at minimising and containing any disaster damage. No additional measures have been required for the office park project.

Project and stakeholder risk management.

Table 8.10 depicts the summarised responses of the case study participants’ responses to interview questions relating to the project and their organisational risk management practices.

Risk management practice aspect	Project. (SA2CR)	Client Rep. (SA2CR)	Architect (SA2A)	Quantity Surveyor (SA2QS)	Structural Engineer (SA2SE)	M & E Engineer (SA2ME)	Main Contractor (SA2MC)
Formal risk management system in place?	No. Partial system. (implicit in project "baseline" document and early warning system).	No. Each partner adopts own procedures.	No. Initial concepts reviewed and tested before commission is accepted.	No. Focus on minimising estimating error. ISO 9001 currently underway.	No. Independent staff design reviews. Outcomes recorded. ISO 9001 being considered.	No. Independent staff design reviews.	Yes (for projects > ZAR25 million). ISO 9000 being considered.
Risk identification processes?	See above.	No risk register. Implicit in project "baseline" document and early warning system.	No risk register. Review and testing process.	No risk register. Phase I used as model.	No risk register. Project files. Review process plus project "baseline" document and early warning system.	Review process plus project "baseline" document and early warning system.	Risk register currently being compiled.
Risk analysis processes?	No.	Spread-sheet financial modelling.	No. Review and testing process.	Spread-sheet financial modelling.	Computer design calculations only.	Computer design calculations only.	Matrix scoring of probability and impact. Spread-sheet financial modelling. Primavera activity programs.

Table 8.10. Case SA2: Project and stakeholder risk management practices.

Risk management practice aspect	Project.	Client Rep. (SA2CR)	Architect (SA2A)	Quantity Surveyor (SA2QS)	Structural Engineer (SA2SE)	M & E Engineer (SA2ME)	Main Contractor (SA2MC)
Responsibility for risk response decisions?	Client representative.	Client representative.	Project leader.	Project leader.	Project leader.	Directors.	Local director.
Risk monitoring and control processes?	Project "baseline" document and early warning system.	Project "baseline" document and early warning system.	Project "baseline" document and early warning system.	Project "baseline" document and early warning system.	Project "baseline" document and early warning system. Increased on-site inspection.	Project "baseline" document and early warning system.	Not yet adopted.
Possible improvement to risk management practice?	Not applicable.	More complete "baseline" document.	Adopt early warning system as standard.	Adoption of ISO 9001.	Adoption of ISO 9001.	Adopt early warning system as standard.	More staff training.
Barriers to more systematic risk management processes?	Not applicable.	Different nature of three consortium partners.	Admin. effort.	Lack of knowledge.	None.	Time.	Staff not familiar with concepts.
Post-contract risk de-briefing process?	Probable (informal de-briefing on Phase 1).	No.	No formal process. Informal post-mortem on some projects.	Cost reconciliation. Informal post-mortem on some projects.	No formal process. Informal post-mortem on most projects.	No formal process. Informal post-mortem on all projects.	No formal process. Informal post-mortem on all projects.

Table 8.10. (Contd.) Case SA2: Project and stakeholder risk management practices.

Risk management practice aspect	Project.	Client Rep. (SA2CR)	Architect (SA2A)	Quantity Surveyor (SA2QS)	Structural Engineer (SA2SE)	M & E Engineer (SA2ME)	Main Contractor (SA2MC)
Risk communication media?	Project	Project	Project	Project	Project	Project	Project
	"baseline" document.	"baseline" document.	"baseline" document.	"baseline" document.	"baseline" document.	"baseline" document.	"baseline" document.
	Contract agreement.	Contract agreement.	Contract agreement.	Contract agreement.	Contract agreement.	Contract agreement.	Contract agreement.
	Meeting minutes.	Meeting minutes.	Meeting minutes.	Meeting minutes.	Meeting minutes.	Meeting minutes.	Meeting minutes.
		Letters, telephone, faxes, e-mail.	Letters, telephone, faxes.	Letters, telephone, faxes, e-mail.	Letters, telephone, faxes, e-mail.	Letters, telephone, faxes, e-mail.	Letters, telephone, faxes, e-mail.

Table 8.10. (Contd.) Case SA2: Project and stakeholder risk management practices.

None of the stakeholders interviewed has any formal education or training in risk management, and all rely on their experience and intuition to deal with project risks.

Although no explicit, systematic process of risk management can be identified on this project, it does display a moderate level of systemisation. The evidence of this is seen in the stakeholder references to the "baseline document" and the "early warning system". Both were instigated by the project manager on the preceding Phase 1 project (NB. Full project management services were contributed by one of the three client consortium partners for the earlier project, and preliminary planning and updating of the "baseline" document for Phase 2). However, both also lack essential features of a comprehensive risk management system. They do not refer to the discrete elements of risk management (risk identification, risk analysis, risk response, and risk monitoring and control), and tend to focus more upon selective risk identification, monitoring and control, ignoring quantitative or qualitative risk analysis and formalised risk response procedures.

None of the interviewed project stakeholders, except the main contractor, exercise formal risk management practices within their own organisations, but the quantity surveyor (SA2QS) is currently testing ISO 9000 quality assurance systems implementation, and the structural engineer (SA2SE) and the main contractor (SA2MC) are considering similar implementations.

The risk management system adopted by the main contractor is in the early stages of implementation, and is intended to be applied to projects exceeding ZAR25 million in value, so it

is not strictly relevant to Project SA2. The value limit was chosen arbitrarily as a means of selectively introducing the system. The system incorporates brainstorming among key staff (directors, estimators and contracts managers) as a risk identification tool, and categorising the risks in terms of the operational divisions of the company. This approach will eventually be augmented by a risk database (register) as this is built up through project experience. Risk analysis is intended to be carried out mainly through a risk severity matrix approach (Chapter 3), using 10 point Likert scale scoring for the probability and impact dimensions of risks in order to create a ranked list of project risks. Examination of the limited documentation available for this system indicated that early review and adaptation would probably be necessary. Other staff (planners and purchasers) should be included at an early stage; the scoring system is probably over-fine; existing and missing risk control mechanisms need to be clearly identified, as well as proposals for on-going monitoring of some risks. At the time of interview, the system had not been fully applied to a live project, and was being trialled in parts. Nevertheless, it was the only formal risk management system encountered in the case studies.

For the design consultants, internal design reviews are an essential contributor to identifying and analysing risks, and deciding upon responses.

Use of computerised systems for exploring risk analysis was limited to spreadsheet based financial modelling and design calculation software, but without probabilistic data treatment other than simple replacement of key variable values on a "what if?" basis.

The consultant stakeholders (ie. excluding the main contractor) thought that the "baseline" document and early warning system used on this project had improved their risk management capability. Those who were involved in adopting ISO 9000/1 also thought that this would substantially contribute to more explicit risk management in their organisations. With the exception of the main contractor (SA2MC), they did not foresee a subsequent need for a distinct, formal risk management system as well.

On the basis of his brief exposure to formal risk management, the main contractor (SA2MC) believed that extensive staff training would be necessary to make such systems effective.

In all stakeholder organisations, decision-making power was strategically located at the project leader/director level.

None of the stakeholders consistently undertakes a formal de-briefing process on all projects undertaken by their organisation. Most, however carry out informal post-mortems on at least some projects. These appear to be projects where some sufficiently memorable learning (technical or risk-related) has occurred. The quantity surveyor and the main contractor carry out cost reconciliation procedures on all projects.

The contract agreement was the most explicit risk communication medium identified by interviewees on Project SA2. For the client representative and consultant stakeholders, however, the “baseline” document and early warning system ranked a close (and more practical) second.

The findings about risk management practice to be drawn from the interviews with Project SA2 stakeholders are that:

- A limited systematisation of risk management is observable in the project but, except for the main contractor, none of the stakeholders has adopted formal and systematic risk management processes.
- Accredited quality assurance systems are seen as a substitute for risk management by some of the project consultants.
- Risk identification processes are undertaken mainly in design review meetings, and are not explicit.
- Little or no project or stakeholder organisational risk analysis is carried out, apart from limited use of spreadsheet financial modelling and design calculation software.
- A limited amount of risk monitoring and control takes place on the project through the “early warning” system inherited from the previous Phase 1 project.
- Little risk de-briefing occurs after projects have been completed.
- Stakeholders are not familiar with the processes of formal risk management.
- Shared understanding of project risks is assumed to be achieved through the formal contract agreement and the project “baseline” document.

Implications of organisational structure.

The organisational structures identified within case study Project SA2 comprise:

- Project: temporary administratively-ordered, simply structured professional bureaucracy.
- Client: simple structure.
- Architect: administratively-ordered simple structure.

- Quantity surveyor: administratively-ordered, divisionalised professional bureaucracy.
- Structural engineer: administratively-ordered, divisionalised professional bureaucracy.
- Mechanical and electrical engineer: administratively-ordered simple structure.
- Main contractor: administratively-ordered, divisionalised structure, with simply-structured local division.

For the divisionalised organisations, the location of decision-making power, and the short lines of authority (vertical decentralisation), should help to avoid potential communication difficulties. The prevalence of simple organisational structures for this project and its stakeholders should further assist in ensuring effective project communication, although they are vulnerable to the demise or removal of key staff. The learning experience of the Phase 1 project has been a valuable resource for all stakeholders, but the substitution of the architects for the Phase 1 project manager, as lead consultant on Phase 2, caused some initial confusion in communication.

Risk profiling.

The interviewees' perceptions of their own risk profiles (professional and personal) are shown in Table 8.11.

Risk Profile	Client Rep. (SA2CR)	Architect (SA2A)	Quantity Surveyor (SA2QS)	Structural Engineer (SA2SE)	M & E Engineer (SA2ME)	Main Contractor (SA2MC)
Professional risk profile.	Risk averse.	Risk averse. (practice is risk seeking)	Risk averse.	Risk averse.	Risk averse.	Risk seeking.
Personal risk profile.	Risk averse, but moderate risk seeker in leisure activity	Risk averse, but moderate risk seeker in leisure activity	Moderate risk seeker.	Moderate risk seeker.	Risk averse.	Moderate risk seeker in leisure activity.

Table 8.11. Case SA2: Stakeholder perceptions of their own risk profiles.

While risk aversion was the dominant stakeholder professional risk profile, the main contractor (SA2MC) noted that his company's profit motive forced it to be risk seeking in terms of bidding, or negotiating, for new work. Its adoption of a risk management system, however, showed that it was only prepared to seek risks on an informed basis.

The data support the view that stakeholders are able to maintain a separation between their personal and professional risk profiles.

Table 8.12, read horizontally across each row, displays interviewees' perceptions of the professional risk profiles of other project stakeholders. None of the interviewees was prepared to offer an opinion of the personal risk profiles of others.

Stakeholder:	Client Rep. (SA2CR)	Architect (SA2A)	Quantity Surveyor (SA2QS)	Structural Engineer (SA2SE)	M & E Engineer (SA2ME)	Main Contractor (SA2MC)
Client Rep. (SA2CR)	≡	Risk seeking.	Risk averse.	Risk averse.	Risk seeking.	Estimator: risk seeking. CM: risk averse.
Architect (SA2A)	Risk averse.	≡	Risk averse.	Risk averse.	Risk averse.	Risk averse.
Quantity Surveyor (SA2QS)	Risk averse.	Risk averse.	≡	Risk averse.	Risk averse.	Risk seeking.
Structural Engineer (SA2SE)	Risk averse.	Risk averse.	Risk averse.	≡	Risk averse.	Risk averse.
M & E Engineer (SA2ME)	Risk averse.	Risk averse.	Risk averse.	Risk averse.	≡	Risk averse.
Main Contractor (SA2MC)	Risk averse.	Not known.	Not known.	Not known.	Not known.	≡

Table 8.12. Case SA2: Stakeholder perceptions of other stakeholders' professional risk profiles.

While the consultant stakeholders tended to perceive all the other stakeholders as professionally risk averse, the client representative (SA2CR) saw the architects as risk seeking in terms of their need to consider innovative design solutions to project constraints. He thought the mechanical and electrical engineering consultant might be risk seeking because the consultancy was small in comparison to the volume of work that it undertook. He also detected a shift in the main contractor's professional risk profile; from being risk seeking in obtaining work, to becoming risk averse in maintaining profits on work being carried out. The quantity surveyor (SA2QS) perceived the main contractor to be risk seeking throughout the procurement process.

The consultant stakeholders, and the main contractor, perceived the project client as being risk averse because of the "piecemeal" approach adopted in marketing and developing the whole site, and because of the inclusion of a bank in the client consortium.

Risk "stories".

As with the other two case studies, few actual risk occurrences were recalled by interviewees. Two instances of flooding were remembered (SA2CR and SA2MC), but in both cases prior precautionary action had minimised the potential impact to the point where no damage had actually occurred. The fact that these instances were recalled suggests that it is not always necessary for great damage to be caused – or for the risk event to actually occur – for risk learning to take place.

Specific evidence of risk learning is shown in the lightning strike incident recalled by the mechanical and electrical engineering consultant (SA2ME). The original design precautions had recognised the above average risk of lightning strikes in the region where the project was located, but these precautions were not sufficient to provide complete protection to the electrical system during a severe electrical storm when lightning actually struck the building (the risk event) and caused damage to control panels. Further protective measures were subsequently installed. Since then, the majority of the existing buildings in the region (an industrial area) have been up-graded in terms of lightning protection, and additional precautions included in the design of new projects. In this instance, the risk learning had a "ripple" effect, spreading beyond the directly-affected stakeholders by word of mouth and notices from the local regulatory authority to other consultants and nearby building owners.

The other risks identified by interviewees tended to be either "third party" events (eg. theft occurring on site) where responsibility was contractually transferred to the contractor (and thence to sub-contractors); or situations where pre-emptive action had been taken to avert the risk (eg.

pre-purchasing equipment to avoid exchange rate fluctuations). It was clear that interviewees recognised risks, particularly those directly affecting their sphere of operations. What was less clear was how they dealt with them, particularly those which could not be assigned through the conditions of contract. Of particular note, however, was the recognition of managerial risks in terms of human resource management. While the loss of key staff was seen as a serious and continuing risk by three consultants (SA2A, SA2QS and SA2ME), responses to it were more haphazard than systematic. In the case of SA2QS, for example, salary reward and responsibility were not sufficient to retain three key staff members.

8.5. Inter-project comment on case studies

Project riskiness.

In terms of the criteria proposed by Smith (1999), none of the case studies can be described as a high risk project. No innovative technology is required, nor are any novel methods of procurement or construction necessary. None of the projects is large or complex in scope, and no regulatory changes are anticipated which could impact seriously on the projects. The stakeholders are generally experienced for their roles in project procurement. While the two South African projects could be described as being in a developing country, the relatively sophisticated nature of the South African economy and its construction industry suggest that neither can be considered as immature. Similarly, Singapore has a developed economy and a carefully-regulated, internationalised construction industry.

From a client point of view, Project SA1 more risky than Project S1. S1 has a fixed price contract under a design-build procurement system. SA1 is a cost fluctuation reimbursement contract utilising a conventional separated procurement system. Effectively, the client for S1 has transferred all design and price risks to the contractor. For SA1, the client still bears a substantial proportion of these. Any unforeseen increases in the costs of labour and materials (beyond the contingency allowed in the project cost plan) will adversely affect the project budget for SA1. The management of this economic risk has been left to the quantity surveyor, who is using hidden contingency provisions to deal with it.

Despite its speculative nature, Project SA2 is probably less risky than Project SA1. The contingency provisions are transparent and known to the client. While a separated procurement system has been adopted, the contract price has been negotiated with the same contractor who

built the previous phase, which has also provided a learning template for the consultants and sub-contractors. The short contract period reduces the client's exposure to the economic risk of unforeseen increases in inflation. Through its use of the "baseline" document and "early warning" system, Project SA2 shows a higher level of implicit risk management than Project SA1, although the latter's quantity surveyor (SA1QS) has taken the precaution of trying to engage the contractor more closely in the project cost control process. Even though the computer equipment is excluded from the current project budget for Project SA1, the estimates do include for furnishings and the costs of these must be uncertain at this stage since little is known about them.

Project S1 is marginally less risky than Project SA2. For the client, the fixed price, design-build contract provides better security for time and cost. The project itself is a simple factory shell and, although building quality might be an issue under the design-build contract, the adjoining existing factory building provides an indication of the quality sought by the client.

Given these arguments, it may be concluded none of the three case studies is a high risk project; that Project S1 is the least risky, and that Project SA1 the most risky.

The comparison between the three projects is superfluous in that there is no real need to know which project is the most risky, since the case study projects are not alternatives in a single decision-making process. The value in the comparison lies in testing the criteria proposed by Smith (1999), and these would have to be seen as inadequate as they are currently stated.

For example, it is probably less important to know whether or not the project requires new technology or novel methods than it is to know if these will be *new to the user*. Similarly, without standard reference points, project size and complexity may be perceived differently by different stakeholders. The "extreme time constraint" criterion would have to be benchmarked in some way, as also would the degree of stakeholder experience. The latter might be measured in different ways, including years of establishment for the stakeholder company; years of project staff experience at different levels of responsibility, total number of projects completed, or numbers of projects of relevant types completed.

Surprisingly, perhaps, interviewee responses in assessing the riskiness of the three case study projects showed that other stakeholders had some difficulty in determining how sensitive the clients' interests were to the time, cost and quality outcomes of projects, and also in prioritising these. The data suggest that, while stakeholders recognised the overall importance of the client's time, cost and quality objectives for the project, they tended to give more emphasis to those most

relevant to their individual role in the project. This gives support to the research findings of Bowen *et al.* (1999) which revealed that the client's brief was not always effective in communicating project objectives to other stakeholders.

A riskiness criterion not noted by Smith (1999), but detectable in the Technikon computer centre project (Case Study SA1) is that of *novelty of project function*. Interviewees on this project indicated that the formulation of a project brief had proved difficult because the intended function of the building was not known with precise certainty beforehand, and no existing buildings of similar function were available as an example. The spatial planning for the building had been dictated largely by the available site and the scope of similar academic buildings nearby, and by an assumption about the number of incoming students who would actively seek (as opposed to need) self-help computer literacy tuition facilities. The assumption was that all students would make use of them – tantamount to a risk avoidance measure. Similarly, no forward planning had been undertaken about the continuing future use of the building, when the need for computer literacy upgrading was no longer considered urgent or necessary. Again, an assumption had been made that an appropriate future use would readily be found.

The same case study reveals another riskiness criterion – *the extent of client financial responsibility for the project*. Previous building projects for the Technikon had all been fully funded by the central government. While careful cost planning for these projects had presumably been undertaken, as part of the public sector accountability process, the fact that this funding had been targeted at socially and politically disadvantaged communities had (according to the interview remarks of SA1QS) resulted in a somewhat relaxed view towards extra project spending for variations. For Case Study SA1, limited government funding had left a substantial shortfall which the Technikon would have to make up from other sources, such as appeals to industry. While the Vice-Chancellor was confident that this could be achieved, he was aware that there was no longer a bottomless purse for final costs, and was concerned that this awareness had not penetrated the consciousness of all the other stakeholders. This point was made during a campus meeting attended by the interviewer, where the Vice Chancellor addressed staff and stakeholder representatives.

Examination of Case Study SA1 gives rise to perhaps a further project riskiness criterion – *propensity to retain unique design features*. The proposed tensile membrane roof proposed for the atrium area of the computer centre building is a design feature likely to create conflict between the architect - anxious to retain it for its aesthetic image, and the quantity surveyor, who may be struggling to maintain the project budget. The client's eventual decision may well be an umpiring

one, but neither the Vice-Chancellor nor the project manager (SAIPM) is currently aware of this potential issue.

The relative importance of *intra*-project risk factors may need to be weighted differently for different projects, as the Smith (1999) project-riskiness criteria are not ranked.

Finally, no conclusions about the riskiness of a project would be complete without some assessment of the level of formal risk management systems to be used in it (at a project level and within key stakeholder organisations). This would entail benchmarking, in some manner, system performance relating to each of the processes of risk identification, risk analysis, risk response and risk monitoring and control. It is unlikely that such benchmarking could be precise or highly quantitative, since time would probably not allow this. The issue of who would assess the risk management system performance is also difficult.

These findings suggest that further research, into assessing the riskiness of projects, is warranted. Such research should focus upon the qualitative aspects of Smith's (1999) criteria, since there are many quantitative appraisal models available to explore the dimensions of issues such as financial risks.

Project and stakeholder risk management.

Only one stakeholder (SA2MC) among the three case studies was found to employ a formal system of risk management. Even that system was in its infancy and limited to larger projects in its application.

Generally, the case study analyses have shown that stakeholders use partial, implicit and informal *ad hoc* processes for managing both project and organisational risks. Some interviewees found difficulty in distinguishing clearly between project risks and their organisational risks, but this may have been due to the interview process itself, which was guided rather than rigidly structured by the design protocol. Implementation of ISO-accredited quality assurance systems was often perceived as a substitute for formal organisational risk management.

Stakeholders' project risk identification tended to be based upon experience. For design consultants this is frequently reinforced by critical peer review during the design process. Quantity surveyors might use project query lists. Where explicit amplification of the stakeholder roles and responsibilities, and project requirements was made available (eg. the "baseline document" in Case Study SA2) this was seen as a valuable risk identification tool, as also was a

project early warning system of flagging potential problems. Consultant stakeholders consistently identified their organisational risks as relating to professional liability, in effect mistaking the risk impact for the risk event.

Virtually no explicit, quantitative risk analysis procedures were detected across all three case studies. Computerised project design calculation programs, and spreadsheet-based financial modelling tools were used by consultants in their respective roles, but no actual modelling of the probability and impact of project risks was undertaken. At most, project calculations and appraisals were subjected to “what if?” sensitivity testing of uncertainty by simple replacement of single variable values. No evidence was found of any comprehensive *intra*-organisational stakeholder risk analysis. This was particularly so with respect to the probability and time dimensions of risks, as stakeholder interviewees’ responses generally ignored these and tended to focus instead upon risk impacts.

This is an area where applied research might be used to test the practicality of using (or developing) existing risk analysis software programs for construction projects, and for stakeholder organisations.

Responsibility for risk response decisions was found to be located at appropriate levels in all project and stakeholder organisational structures although, given the absence of formal risk management systems, it was evident that it would not always be clear that the decisions being made were actually risk-related.

Other than the “early warning” system used on Case Study SA2, little evidence of explicit project risk monitoring and control processes was found in the three case studies. Even this system was primarily aimed at identifying potential new risks rather than monitoring existing ones. Project site meeting minutes were generally thought to most closely fulfil this role. For stakeholder organisational risks, ISO-accredited quality assurance procedures were again seen as a substitute for risk monitoring and control, as also were regular director and staff meetings.

Most stakeholders in the three case studies focussed upon their own organisations in discussing possible improvements to their risk management practice. Suggestions included implementing a more formal system; formalising the decision-making process; and adopting ISO-based quality assurance systems.

Reluctance, to embrace yet another “management system”, would summarise stakeholder responses to identifying barriers to the implementation of more systematic project and organisational risk management processes. The time required to introduce and operate such systems, and the need for comprehensive staff training, were also seen as barriers.

The same reasoning probably explains the general lack of formal post-project de-briefing (risk-related or otherwise) found among the interviewees’ stakeholder organisations. Where de-briefing did take place, it was not consistently undertaken for all projects and was limited to cost reconciliations (the quantity surveying consultants) and informal team reviews (the design consultants). Some noting of issues took place at these de-briefings, which invariably took place within individual stakeholder organisations rather than collegiately at a project level. The probability, impact and duration of experienced risk events are rarely analysed in detail or formally recorded for future use.

The contract conditions of agreement were most commonly perceived as being the primary medium for communicating project risks. When a comprehensive client brief was provided (eg. Case Study SA2) this was seen as an excellent communication medium for both project and stakeholder risks. For stakeholder organisational risks, no single communication medium was preferred, and suggestions ranged from “word of mouth” to the ubiquitous ISO 9000 quality assurance documentation. The research was actually looking for evidence of some degree of systematic and formal communication between project stakeholders about specific project risks during the procurement process before the drafting of the contracts, but only the “baseline” briefing document of Case Study SA2 appeared to satisfy this requirement.

Implications of organisational structure.

In terms of the Mintzberg (1979) and Parkin (1996) classifications, the three case study projects are all temporary, administratively-ordered, simply structured professional bureaucracies. Their relatively compact vertical and horizontal centralisation should assist in promoting effective decision-making and communication. As with all simple organisational structures, however, they are vulnerable to any unexpected loss of one or more of the key participants.

In all three case studies, the organisational structure for each project was intended to channel client/stakeholder communication through the project manager (or lead consultant, SA2A, in Case Study SA2). However, for the Technikon computer centre project (Case Study SA1) the quantity surveyor (SA1QS) had retained a direct link (for all cost-related matters) with the project manager (SA1PM), effectively allowing the lead consultant (the architectural joint venture consultancy) to

be by-passed (Fig 8.5). While no sinister intent was detected in this arrangement (SAIQS claimed that it was intended to ensure that the client received full and correct cost information, and that such links commonly "oiled the wheels" of all projects), it has the potential to give rise to communication error. It is unlikely that this was the only non-transparent communication channel among the three case studies, although no others were detected, and its existence suggests that project organisational structures may actually operate in a more complex manner than the simple structures portrayed for them.

Individual stakeholder organisations in the case studies tended to be either divisionalised professional bureaucracies (eg. the quantity surveyors) or simple structures (eg. the architects). The divisionalised organisations have avoided the decision-making and communication difficulties associated with this type of structure by maintaining small, simply-structured internal divisions, and by locating decision-making powers at appropriate levels within them. The links between the stakeholder organisations and their respective project organisations should therefore be relatively trouble-free. This may not be entirely true for the joint venture stakeholders on Case Study SA1, in that neither of the joint venture consultancies appears to have established decision-making hierarchies or communication channels which are sufficiently transparent to other project stakeholders.

One unresolved issue arises from the examination of the organisational structures of the case study projects and their stakeholders.

The temporary nature of project organisations precludes group risk learning in them other than on a short term basis. Within the more permanent stakeholder organisations, while the risk learning may be more permanent, the simple structures and divisionalised forms of professional bureaucracy, with their emphasis on individuals as the essential operating units, will tend to capture risk and risk management experiences anecdotally and informally in a few individuals, compared with less centralised organisations where data collection is likely to be more systematic and explicit (as a means of controlling them effectively). Any risk learning that does take place within highly-centralised stakeholder organisations is likely to be sporadic, haphazard and vulnerable. This cannot be stated categorically as a finding of this research, but it may be a preliminary hypothesis for future research. If the hypothesis is true, it reinforces the need for project stakeholder organisations to adopt more formal risk management practices, so that the benefits of risk learning are gained organisationally. Greater use of formal project de-briefing, and obtaining client feedback, would also help in this regard.

Risk profiling.

Across the three case studies, personal risk attitudes do not appear to influence professional risk attitudes. In any case, most project stakeholders saw themselves as both personally and professionally risk averse. Interviewees who did see themselves as professionally risk seeking were careful to explain that this was in the context of seeking work in a competitive market, and not in carrying out their work on a particular project. This is tantamount to a shift in risk attitude, but only one interviewee (SA2CR) actually suggested that a stakeholder's risk attitude might change during successive stages of a project (ie. the contractor changing from pre-tender risk seeking to post-tender risk aversion), thus supporting McKim's (1992) findings. The quantity surveyors tended to take a stereotypical view of contractors as being professionally risk seeking.

If project stakeholders are generally professionally risk averse, then risk attitude is unlikely to have an uneven effect on strategic project decision-making.

Risk "stories".

The recounting of direct risk experiences was the least satisfactory aspect of the case study investigation. The data richness sought through these "stories" from project stakeholders was simply not forthcoming: interviewees seemed generally unwilling or unable to recall real risk experiences in any detail.

In retrospect, there was almost certainly a cultural barrier operating during the interview processes for the Singapore factory project (Project S1), as a greater willingness to discuss risk events was found in the two South African cases. Even so, the number of risk "stories" was disappointing, given the popular view of the risk-laden nature of construction projects (Flanagan and Norman, 1993) and the risk catalogue given to interviewees as a reminder.

The nature of the risk recollections was also somewhat limited. Only six "stories" related to first hand risk experiences. Of these, one related to the natural (geotechnical) risk arising from a basement excavation design (S1SE); two to the natural (weather systems) risk of flooding (SA2CR, SA2MC); one to the natural (weather systems) risk of lightning strike (SA2ME); one to the human (political) risk of industrial relations action (SA1SE); and one to the human (technical) risk of estimating for a feasibility study (SA1QS). Of these, only one (lightning strike; SA2ME) actually resulted in an adverse impact, and even then the damage was considered minor by the interviewee (although the subsequent risk learning from this event was spread beyond the project stakeholders).

The remaining "stories" found in the case study studies comprised either interviewee's recollections of second hand risk events (ie. risks which had occurred but in which they had had no direct responsibility) or opinions about mitigation or avoidance of potential risks which interviewees had selected from the given list.

The incidence of natural risks in the first-hand stories suggests that natural risk events (e.g. floods, lightning strikes) may have a powerful effect on memory. Interestingly, none of the interviewees recalled any site accident events involving injury or death, despite the statistical chance of such events occurring likely to be greater than that of natural risks. It may be that risk "memory" is selective. Given the importance of learning in risk management, this could be a fruitful area for future construction management research.

As noted earlier with risk management practice, stakeholder interviewees' risk stories persistently ignored the probability and time aspects of risk: at best their recollections were limited to some indications of risk impact.

If interviewees were reluctant to recount their real, direct risk experiences in any detail, then the case protocol design (Chapter 7) must be blamed. Although this design was deliberately intended to be a loose guide for an informal interview structure, the recollection of risk "stories" occurred towards the end of each interview, after interviewees had been responding to other issues for upwards of an hour. While "respondent question fatigue" was not detected by the interviewer, its effect cannot be completely discounted.

On the other hand, if interviewees were genuinely unable to remember any direct risk experiences, this may suggest that construction projects are generally less risky than has been intimated in the literature; that stakeholders do not use risk experience as claimed in the literature; or that existing implicit levels of project risk protection, in terms of avoidance, mitigation and transfer, are more effective than the literature suggests.

The lack of clear evidence from the case studies, about how risk learning actually occurs and how it may influence subsequent project decision-making, is disappointing. It also precluded any investigation of the information primacy/recency hypothesis noted in Chapter 4. Case-based research would still appear to be an appropriate approach to investigate all the hypotheses posed above, but a more microscopic investigation, and even a more involved "action research" methodology (applied to live projects) might be necessary. An alternative approach, such as

experimentation using hypothetical scenarios, might not engender sufficient realism to produce reliable results. This aspect of risk management research needs further methodological debate.

8.6. Conclusions

In this chapter, a case study approach, involving three current projects, has been used to explore questions relating to risk and risk management for construction projects. The analysis of data collected through interviews with key project stakeholders, using simple content analysis and pattern matching, allows several conclusions to be drawn.

While project stakeholders appear to have broadly similar perceptions of project risks, these are seen in the context of the project objectives. If there is a lack of a common, or consistent, view of the project objectives (i.e. a failure of the project brief to communicate effectively), then stakeholders are likely to place different priorities on different risks, and their priorities are likely to relate to the focus of their particular involvement with the project.

Criteria currently advocated for assessing the riskiness of construction projects are insufficient. In order to make more reliable assessments, benchmarking of measures such as project size, complexity, time constraints and stakeholder experience is necessary. Technical complexities of projects need to be assessed in terms of their novelty to the user. Additional criteria might include: extent of functional novelty of the project; the nature and extent of the client's direct financial responsibility for the project; and the propensity of the project designers to retain unique (but conventionally replaceable) design features. It may also be appropriate to benchmark the existence, nature and extent of any formal risk management systems to be used on the project and within stakeholder organisations.

The case study projects confirm the starting point of the research: that construction project risk management practice is currently neither formalised nor systematised. Current risk management practice does not deal comprehensively with any of the three components of risk: probability, impact and time. It focuses on risk transfer (through contractual assignment down the supply chain) rather than risk retention and reduction. It tends to regard time, cost and quality objectives of projects as risks *per se*, rather than as potential adverse impacts /victims of the consequences of risk events.

Apart from the risk allocation inherent in their respective standardised forms of contract, project risk management on the three case study projects tended to be informal and implicitly carried out within the various stakeholder roles. Brainstorming of issues and design concepts was undertaken through peer review processes within some stakeholder organisations. This process acted as an approximate method of risk identification. Virtually no formal, quantitative analysis of risks (project or organisational) was carried out, as stakeholders thought this unnecessary. Project risk response was regarded largely as a matter of contractual transfer, or dealt with by the inclusion of arbitrarily-determined contingencies. Little or no monitoring and control of risks was envisaged for the three projects; nor was any extensive post-contract risk de-briefing planned.

Several interviewees believed that their organisational quality assurance processes were an adequate substitute for organisational (and, to some extent, project) risk management. However, quality assurance is concerned with consistently getting the right outcomes from known processes; while risk management is about proactively dealing with the possibility and consequences of things going wrong.

The organisational structures of the case study projects and their stakeholders revealed that, for the most part, the simplicity of the structures would contribute towards effective communication, although the existence of non-transparent channels could affect this (positively or negatively). Decision-making was appropriately located in the stakeholder organisational structures. However, the focus upon individuals within most project and stakeholder organisations renders these organisations vulnerable to loss of key staff, and their lack of formal risk management systems limits their capacity for organisational (as distinct from individual) risk learning.

Despite their limitations in terms of risk management, however, it was clear that none of the case studies could be regarded as a high risk project. Each was enveloped in a cocoon of professional prudence, whether viewed from the perspective of the client representative, consultant or contractor. In most instances this might be attributed to the professionally risk averse attitude of the project stakeholders. The enigma of the dearth of case study risk "stories" suggests that this prudence does not necessarily arise from the learning gained from direct risk experiences. It is possible that professional education and training play a substantial part as project stakeholders bring these to bear upon their work.

The value of the findings of the case-based research may lie more in theory-building, rather than theory-testing. Specifically, they suggest that future research effort might usefully be directed towards developing a better theory of practice of risk management for construction projects. Risk

management itself is a relatively well known business tool, used in both public and private organisations, and in industries as diverse as banking and finance, insurance, mineral and oil exploration, and petrochemicals. If risk management systems are substantially developed (and applied) in other industries, why is this not so in the construction industry and how can the situation be resolved? Why are the probability and time dimensions of risk persistently ignored? How might the performance of risk management practice be measured and benchmarked? What substantive links exist between formal risk management and accredited quality assurance processes?

Essentially these are questions beyond the scope of the present research, but they are suitable topics for future research. Each of the four elements of risk management (Chapter 2: risk identification; risk analysis; risk response; and risk monitoring and control) warrants closer examination, particularly from the perspectives of *intra*- and *inter*-organisational application and communication among project stakeholders.

A better theory of practice of construction risk identification would suggest ways in which greater transparency of risk understanding could be achieved between stakeholders. What are the project and organisational risks? How should project teams go about identifying them? What media would best serve to record, communicate and allocate them?

A better theory of practice of construction risk analysis should demonstrate how the effects of all three components of risk (probability; time and impact) might be assessed, and how these might vary for each stakeholder.

A better theory of practice of construction risk response would identify the decision-makers and establish reliable criteria for deciding between alternative risk responses.

A better theory of practice of construction risk monitoring and control would examine how this process could be achieved with a sufficient level of transparency between stakeholders.

Ideally, a better theory of practice of construction risk management would locate the management of project risks firmly in the initial briefing phase of projects, establishing risk management plans as an integral and seamless part of the whole procurement process. Each stakeholder would be aware and informed about them, and be responsible for showing how their own organisational risk management would complement the project risk management.

Given the development and implementation of a theory of practice of construction risk management along these lines, the benchmarking potential of such practice could then be realised.

The following Chapter reiterates the main findings of this research, and examines the extent to which the research objectives have been achieved.

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CHAPTER 9

CONCLUSIONS AND RECOMMENDATIONS

9.1. Introduction.

This research has explored risk and risk management for construction projects, focussing upon the way in which risks are perceived and dealt with by key project stakeholders. The research problem was stated (Chapter 1) as:

Construction risk management is poorly understood and poorly systematised in practice. As a consequence, the proper management of risk among project stakeholders may be negatively affected.

Research questions were framed in order to provide a focus for investigating the problem:

- (1) Do individual members of project teams have different perceptions of construction risk?*
- (2) How are these perceptions communicated within a project environment?*
- (3) To what extent is risk understanding influenced by stakeholders' prior risk experiences?*
- (4) If different risk perceptions exist, how does this affect the project decision-making?*

The subsidiary questions necessary to inform these questions included:

- (1) What are risk and risk management?*
- (2) What are construction projects and their environments?*
- (3) What are project and construction risks?*
- (4) Who are the project stakeholders and how does project decision-making occur?*

(5) *What has other research in this field revealed?*

The propositions tested by the research are that:

- (1) *Stakeholders (eg. Client and project team members) in a construction project do not share common perceptions of project risks*
- (2) *Stakeholders' prior risk experiences will influence project decision-making.*

The methodology chosen for the research was broadly ethnographic, comprising discursive review of appropriate literature, questionnaire survey and case studies of construction projects, using a qualitative, rather than a quantitative approach.

In this chapter, the findings of the subsidiary and main research questions are presented; followed by a review of the propositions formulated for the research. Conclusions are drawn from the research findings, and recommendations made for future research and for practice. Finally, the achievement of the research aims and objectives is discussed.

9.2. Findings of the subsidiary research questions.

What are risk and risk management?

The preferred definition of risk was argued in Chapter 2 and found to be that: "*Risk is the probability that an adverse event occurs during a stated period of time.*" (Royal Society, 1991). Unlike other definitions, this includes not only the probabilistic and impact characteristics, but also the essential temporal quality of risk. Risk is a social construct (Chapter 1) in that it is experienced, interpreted and managed by people. Because its characteristics are not necessarily static over time, risk is also dynamic (Chapter 1).

Uncertainty is distinguishable from risk and, for the purpose of risk management, is the relative lack of certainty about information relating to any of the characteristics of risk (Chapter 2). True uncertainty is converted to bounded uncertainty by assumptions, based on judgement, concerning the possible range of values for any or all of the input variables (probability, time, impact) in risk analysis.

Risk management is a systematic approach to dealing with risk (Chapter 2). It takes place within an appropriate context relating to the objectives of the risk taker. Procedurally, a formal risk management system will include procedures to: identify and analyse risks; influence risk decision-making and encourage an explicit risk response. It will also monitor and review risk outcomes over the procurement life of a project. For construction projects, *risk management is placed in the context of project decision-making*.

What are construction projects and their environments?

Construction projects proceed within some form of *organisational system* aimed at achieving the project objectives, of which at least one will be the physical procurement of built facilities (Chapter 4). The environment of construction projects is that of the construction industry, a major contributor to the economy of a nation. In any construction project, stakeholders are faced with three types of problem simultaneously: entrepreneurial (the right project); engineering (the right technology); and administrative (organising the work).

What are project and construction risks?

Project and construction risks are extensive and varied, and attempts have been made to categorise them as an aid to identification in the process of risk management. In Chapter 2 it was argued that a generic approach to categorising risks by their type of source (or trigger) is preferable, as this not only aids identification but may also assist in analysing and responding to risks. Risks are either *natural* or *human*. *Natural* risks arise outside human agencies. *Human* risks arise out of the actions (or in-actions) of people. Natural risks may occur through weather systems, geotechnical systems, and in some instances extra-terrestrial systems. Generic categories of human risk comprise: social, political, economic, financial, legal, health, managerial, technical, and cultural risks.

Who are the project stakeholders and how does project decision-making occur?

Chapter 4 identified a project stakeholder as any entity which has the power to influence project decision-making directly, and a list of stakeholders, relating to the supply chain of construction projects, was compiled. Since the focus of the research was upon early stages of project decision-making, not all of these were targeted in terms of the primary data collection requirements of the investigation.

Decision-making was found to occur within the organisational frameworks of projects. These are influenced by the procurement system adopted for individual projects (Chapter 4). *Procurement systems are either "separated" or "integrated" in terms of the assignment of project design responsibility.* The administrative mode of ordering forms the basis for project organisational structures. Much of the project decision-making in such structures tends to occur within the nodes, typified, for example, by that of a consultant quantity surveyor, whose *intra-organisational* decision-making process (e.g. type of cost model, type of data) is followed by judgement applied in interpreting the outputs and communicating cost advice to the client. The nodal *loci* of project decision-making distinguishes it from other forms of group decision-making, and thus mitigates against the occurrence of *groupthink* in construction projects.

In the main, project risks are allocated through the formal, contractual links in the organisational structures arising from the procurement system adopted for the project. While the conditions of agreement underlying these formal contracts will expressly communicate the allocation of some risks, others will be implicit in terms of the processes foreshadowed for the project (e.g. a contractor's occupational health and safety risks).

What has other research in this field revealed?

Review of the relevant literature (Chapters 2, 3, 4 and 5) revealed a wide research interest in construction risk and risk management extending over more than forty years. Survey-based research conducted over the past decade, however, shows that little of the theoretical exposition of the topic has found its way into practical applications in the construction industry.

9.3. Findings of the main research questions.

Chapters 5, 6, 7 and 8 report the investigation into the main questions of the research.

An opinion survey instrument was designed (Chapter 5) and administered to explore whether or not project stakeholders have different perceptions of risk and risk management. The survey aimed to substantiate issues identified in the literature review and expose any additional issues.

The findings of the survey (Chapter 6) indicate that *differences do exist in the risk perceptions and risk management practices of the various consultants and the contractors involved in construction projects.*

There is also an *international lack of maturity and expertise in risk management in the construction industry.*

Other issues revealed by the survey include the nature of personal risk experience and how it is used intuitively in risk management, and why formal risk management systems are not commonly adopted on construction projects.

Case studies were used for more in-depth exploration of the research questions and issues, and a protocol was designed for the collection of the primary data (Chapter 7). Three current projects were used as case studies and the main findings from this investigation (Chapter 8) show that:

- while project stakeholders have broadly similar perceptions of project risks, these are related to project objectives. If there is no uniform understanding of the project objectives, then stakeholders are likely view risks differently (as confirmed in the survey research of Chapter 6).
- benchmarking of project riskiness measures such as project size, complexity, time constraints and stakeholder experience is necessary; and technical complexities of construction need to be assessed in terms of their novelty to the user.
- additional criteria for assessing project riskiness might include: the extent of functional novelty of the project; the nature and extent of the client's direct financial responsibility for the project; the propensity of the project designers to retain unique (but conventionally replaceable) design features; and the nature and extent of formal risk management intended to be used on the project.

In terms of current project risk management practice, the three case studies showed that:

- it is neither formalised nor systematised.
- it does not deal consistently or comprehensively with any of the three components of risk: probability, impact and time.
- it focuses on risk transfer (through contractual assignment down the supply chain) rather than risk retention and reduction.
- it tends to regard time, cost and quality objectives of projects as risks *per se*, rather than as potential adverse impacts /victims of the consequences of risk events.
- it is informally and implicitly carried out within the various stakeholder roles.
- peer review is often used to brainstorm issues and design concepts, and this acts as an approximate method of risk identification.
- virtually no formal, quantitative analysis of risks is carried out.
- risk response is regarded largely as a matter of contractual transfer.
- little or no monitoring and control of risks is envisaged.
- no extensive post-contract risk de-briefing is planned.
- interviewees believe that their organisational quality assurance processes are an adequate substitute for risk management.
- other than explicit risk allocation through the form of contract between client and contractor, little or no evidence was found of consistent, formal communication of risk-related matters among stakeholders.

The organisational structures of the case study projects and their stakeholders revealed that:

- the simplicity of the structures would contribute towards effective risk communication.
- decision-making is appropriately located in the organisational structures.
- the focus upon individuals within project and stakeholder organisations renders them vulnerable to loss of key staff.
- their lack of formal risk management systems limits their capacity for organisational (as distinct from individual) risk learning through experience.

The majority of the case study stakeholder interviewees perceive themselves as being risk averse, both professionally and personally. Where interviewees do see themselves as personally risk seeking,

this is generally limited to specific leisure pursuits and they feel able to distinguish clearly between a personal risk seeking attitude and a professionally risk averse approach to their work. Interviewees generally perceive other stakeholders as being professionally risk averse. Where stakeholders do perceive themselves or other stakeholders as being professionally risk seeking, this is always in the context of obtaining work competitively, and not in terms of actually carrying out professional tasks. This supports a hypothesis that, for some stakeholders, changes in professional risk attitude may occur over the procurement life of a construction project.

Despite the paucity of interviewees' risk 'stories' from the three case studies, their risk accounts do reveal some findings of value. They tend to confirm that stakeholders focus upon risk impact and generally ignore the probability and time dimensions of risks. They also suggest that risk learning is not necessarily gained entirely from direct risk experiences. Professional education and training are likely to play a substantial part in inculcating attitudes towards, and responses to, construction project risks. Natural risk events (flooding, lightning strike) appear to provoke readier recollection than human risk events; although this is inconclusive since no human risk 'disaster' events (eg. scaffolding collapse) were recounted.

9.4. The research propositions.

The research has tested the proposition that *project stakeholders (eg. client and project team members) do not share common perceptions of project risks*. The proposition was explored through the literature review, opinion survey and case studies (Chapters 3, 4, 5, 6, 7 and 8).

The survey findings of Chapter 6 show that proposition is supported in a general sense (eg. there are differences between the perceptions of quantity surveyors, engineers, project managers and architects). However, at a project level (Chapter 8), greater commonality of perceptions was found, indicating that the organisational nature of projects is instrumental in bringing project stakeholders closer together in their project risk perceptions. This sharing of risk perceptions may be endangered if stakeholders do not also share a clear understanding of the project objectives, thus highlighting the importance of an effective briefing process as a tool for defining these objectives.

The research has also explored the proposition that *stakeholders' prior risk experiences will influence project decision-making*.

Again, the survey findings of Chapter 6 tended to support this proposition. However, the three case studies (Chapter 8) failed to establish clear, direct and measurable links between risk experiences and project decision-making. While this was due in part to inadequacies in the case study design protocol, it is likely that professional education and training largely influence risk decision-making in construction projects, as direct risk learning from personal experience may be too limited to exert this influence alone.

9.5. Conclusions.

The research has shown that the construction industry still has a considerable way to go in demonstrating effective systematic management of risks, at both project and stakeholder organisational levels. Much is left to informal, implicit understanding and approaches in dealing with construction risks. The probabilistic and temporal characteristics of risk are ignored, in favour of a limited and largely intuitive appreciation of potential risk impacts which influences responses to, and treatment of those risks. Because the approaches tend to be piecemeal, informal and implicit, it is possible that many project clients are not aware that the risk management for their projects is limited in this way.

The lack of a formal, systematic approach to managing construction risks also militates against the effective organisational use of risk learning. While the consequences of this may not be unduly serious for relatively low risk “bread and butter” projects, where professional judgement (inculcated through professional education, training and experience) is adequate for project decision-making, its absence is likely to be felt in high risk projects or projects where unusual risk circumstances exist.

9.6. Recommendations.

Future research effort might usefully be directed towards developing a better *theory of practice of risk management* for construction projects.

Risk management itself is relatively well known and well developed in industries such as banking, insurance and oil exploration. While their risks may be industry-specific, management of them is predicated upon a more generic understanding of risk which, as this research has shown, could and should be extended to construction projects and their stakeholders.

Future research should therefore investigate ways in which construction and project risk management can be applied more effectively in practice. In particular, the research should focus on *intra-* and *inter-*organisational communication of risks, to achieve greater risk transparency between stakeholders, and upon the time and motivational constraints impeding the greater use of formal risk management by stakeholders.

It is also recommended that tertiary curricula for professional education and training in the construction disciplines should expose students more fully to formal concepts of risk and risk management. Associations for construction professionals should include these topics in their continuing education and career development strategies and programs.

9.7. Achievement of the research aims and objectives.

The objectives for the research were:

- (1) to extend the present theoretical foundation of construction and project risk management; and*
- (2) to gain insight into factors which affect the effective management of construction risk.*

The first objective have been achieved through the discursive literature review of risk and risk management undertaken in Chapters 2, 3 and 4 of this thesis. Risk, risk management and uncertainty have been more clearly defined. Categories of risks have been proposed, and the context for risk management in construction projects has been shown.

The second objective has been achieved through the conclusions drawn from the analysis and findings drawn from the primary data collection as reported in Chapters 5, 6, 7 and 8 of this thesis. Examination of stakeholder perceptions of risk has been undertaken, and the shortfalls in current construction project risk management have been explored.

The aim of this research was to show how the outcomes can improve risk management procedures for construction projects; encourage a more informed understanding of risk for project participants, and facilitate better project decision-making. While the research points the way, it is not a manual for practice, and cannot therefore achieve this aim entirely on its own. Since there is always “a better way”, and there is always new knowledge to be won, the aim itself must be on-going.

University of Cape Town

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APPENDIX

Copy of Survey Questionnaire (South Africa).

University of Cape Town

Date

To: Senior Manager:

RISK MANAGEMENT RESEARCH

This questionnaire survey forms part of a research project to investigate risk management perceptions and practices in the South African construction industry. It forms part of a wider international survey of risk management practices in Australia and Singapore.

Please participate in this survey, or pass the questionnaire on to the person in your organisation who is more appropriately placed to respond.

Your answers to the questions should relate to **a specific construction project** (rather than giving general answers). Preferably, the project should be in the pre-construction phase; *ie* at the tendering or planning stage.

The survey should take about 25 minutes to complete. Participation is entirely voluntary. The data will remain confidential and will not be used for purposes other than the intended research.

The information you are able to provide through this survey will make a valuable contribution towards increasing our knowledge of risk and risk management in construction. Please mail the completed questionnaire to the address shown above. Alternatively, you may fax it back on **021 689 7564**.

Thank you for your help.

Sincerely,

Paul A. Bowen
Professor

Peter J. Edwards
Researcher

QUESTIONNAIRE SURVEY (CONSULTANTS)

RISK AND RISK MANAGEMENT PERCEPTIONS AND PRACTICES ON SOUTH AFRICAN CONSTRUCTION PROJECTS

Most of the questions can be answered by ticking the appropriate box(es).

Please remember that your answers should relate to a specific current project.

Q1. Your occupation: (tick one box only for prime occupation)

- Architect / Designer
- Engineer
- Quantity Surveyor
- Project Manager
- Planner / Scheduler
- Other _____

Q2. Project location: (tick one box only)

- N Prov.
- NW Prov.
- Mpumalanga
- Gauteng
- O.F.S
- KZ-Natal
- E Cape
- W Cape
- N Cape

Q3. Project type: (tick one box only to identify major component)

- Civil engineering
- Residential
- Commercial
- Industrial
- Health, education
- Community, religious
- Sports and recreational
- Other _____

Q4. Procurement system for project: (tick one only)

- Traditional (design-bid-construct)
- Design and build
- Construction management
- Management contract
- BOT (build, operate, transfer)
- BOOT (build, own, operate, transfer)
- Other _____

Q5. Approximate total project value: (tick one)

- < ZAR 5 million
- ZAR 5 - 20 million
- ZAR 20 - 50 million
- > ZAR 50 million

Q6. What methods of risk identification will be used for this project? (You may tick more than one if appropriate)

- Personal experience
- Historical records
- In-house experts
- External consultants
- Reference to publications
- Risk register system
- Other _____

Q7. What approaches to risk analysis will you use for this project? (You may tick more than one if appropriate)

- Intuition
- Brainstorming sessions
- Decision / Fault tree
- Formal mathematical models
- Computer simulation package
- Other _____

Q8. Will you implement a formal risk management system for this project?

- Yes No

Q9. Are you familiar with the theory and practice of risk management?

- Familiar with theory:
Yes No
- Experienced in practice:
Yes No

Questions 10, 11 and 12 explore your opinion about the potential occurrence, impact and treatment of particular risks which may be associated with the current project you have selected for this survey.

For Question 10, for each risk, tick in **ONE** of the five columns in the first block, to indicate your assessment of the likelihood of that risk occurrence on the current project. (Note: **Rare** = exceptional circumstances; **Unlikely** = could occur at some time; **Moderate** = should occur at some time; **Likely** = will probably occur; **Almost certain** = expected to occur)

For Question 11, for each risk, distribute **30 points** across the six columns in the second block, to indicate the nature and relative magnitudes of the impact of the risk event, should it occur on the current project. (Note: you may allocate different points - or none at all - in each column, but the total should equal 30 for the block)

For Question 12, for each risk, distribute **40 points** across the eight columns in the third block, to indicate how you would prefer to deal with the risk in the pre-construction phase of the project. (Note: you may allocate different points - or none at all - in each column, but the total should equal 40 for the block)

RISK CATEGORIES & SOURCES		Q10. OCCURRENCE					Q11. IMPACT						Q12. RISK RESPONSE							
		Tick one column to indicate the likelihood of this risk occurrence on the current project.					Distribute 30 points among the six alternatives, to indicate the relative impacts of the risk event if it were to occur on this project.						Distribute 40 points among the eight alternatives, to indicate preferred pre-occurrence methods of dealing with the risk on this project.							
		Rare	Unlikely	Moderate	Likely	Almost Certain	Cost Overrun	Time Delay	Quality Reduction	Environment Harm	Property Damage	Injury to People	Ignore (retain)	Retain but price in bid	Reduce Impact	Reduce Likelihood	Reduce exposure duration	Transfer (insurance)	Transfer (contract/sub-contract clauses)	Avoid (re-design or not bid)
Political & Social	Criminal acts(eg. theft, arson, sabotage)																			
	Substance abuse on site (eg. drugs / alcohol)																			
	Industrial relations action																			
Natural Events	Earthquake																			
	Flood																			

Thank you for completing this questionnaire. Please return it in the free-post envelope enclosed, or to:

Peter J. Edwards
Department of Construction Economics and Management
University of Cape Town
Private Bag
Rondebosch 7701

Or fax to:

021 689 7564

If you would like to receive information about the findings of this research (publication planned for April, 1999), please include the following details:

Name: _____

Organisation: _____

Address: _____

Fax No.: _____

E-mail: _____

NB: Filling in this panel will not affect the confidentiality of the data you have provided.