MANAGING DESIGN RISK—COST, TIME AND QUALITY?

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True economy in engineering consists in always designing and building structures, machines and other constructions so that, while they will perform satisfactorily in every way for the functions for which they are required, the sum of their first cost and the equivalent capitalised cost for their maintenance, operation and repairs shall be a minimum. The ordinary notion that the structure or machine that is least in first cost must be the most economical is a fallacy. In fact, in many cases just the opposite is true, the structure or machine involving the largest first cost being often the cheapest.[1]

INTRODUCTION

Every construction project has a substantial element of design in it, whether the employer or the contractor engages the designer. In percentage terms, the cost of design is generally a small part of the overall cost of a construction project, and a very small part of the overall cost of a project considered over its life cycle. However, as it is the design that determines not only the form and nature of the construction, but also the characteristics of the constructed facility that determine the ongoing operating and maintenance costs over its entire life, its importance is substantially greater than the proportion of its percentage cost of the project.

The employer in a construction project has a real interest in ensuring that design risks are appropriately managed to ensure, to the greatest extent possible, that the final constructed facility will fulfil its expectations. Equally, the designer has its own commercial interest in managing the design appropriately so that its own commercial and other objectives are fulfilled. This paper explores the ways in which design risks can be managed by the employer, as well as by the designer. It looks at the nature of design in the context of construction projects, and who typically carries it out, and then identifies what are the significant design risks. Those risks are looked at from the perspective of who should bear them, contrasted with the situation of who typically bears those design risks. A number of common issues in mismanaging design risk are reviewed, followed by some suggestions as to good practice in minimizing design risk. The fundamental thesis of this paper is that, because of the fundamental importance of design to the functionality and overall cost of a constructed facility, the quality of design is of overarching importance in construction contracts. The corollary of this is that sufficient time and cost need to be devoted to the design to ensure that the appropriate quality is achieved.

WHAT IS DESIGN?

Some appropriate dictionary definitions of design are: 'to intend for a definite purpose' or 'to form or conceive in the mind; contrive; plan'.[2] Another which encapsulates the essence of design in a construction context is: 'formulation of an idea and turning it into a practical reality'.[3]

For the purposes of this paper, design is taken to include all plans, drawings, sketches, instructions, and descriptions that determine the way the works (or parts of it) are to be constructed. Design includes the writing or selection of specifications, as well as the production of plans and drawings and any element of choice on the part of the designer, such as requirements as to materials or working methods. Many modern construction projects typically involve a significant element of computer software, the writing of which is an important design task.

It is clear from these definitions that an essential distinction between the design task and

the construction task is that the former exclusively involves the production of intellectual property (IP), whereas the latter involves the assembly of components of real property into a constructed facility on the land. In legal terms, a contract for design is a contract for services (typically considered to be professional services) whereas a contract for construction is a contract for goods and services, the services in this case being the labour applied to the goods to construct the facility, as well as the IP required for whatever design the contractor must supply.

The design of a facility involves all the large and small decisions required, inter alia, to determine its form, how it elements work individually and in combination to fulfil their functional requirements, what materials will be used in construction, how these are connected together, how the facility is to be constructed, and how it should be operated. Decisions made during the design of the facility will dictate how it will need to be maintained to retain its functionality, what the operating costs will be and the ultimate design life. In the context of a specific construction project, 'design' may also include the selection of appropriate equipment to be incorporated in the facility or even an entire manufacturing process; the original design of such equipment or process has been prepared previously, and that design IP is already embedded in the equipment or process.

The European Federation of Consulting Engineering Associations (ECA) is currently engaged in discussions with the European Commission on defining the professional services provided by consulting engineers as intellectual services. ECA submit that these services should not be subjected to the same criteria often used for the procurement of goods and construction services. If successful, the discussions should support the use of Quality Based Selection (QBS) as the primary method for the procurement of engineering services in Europe, something that the Federation International des Ingenieurs–Conseils (FIDIC) has long championed.[4]

The design of a facility thus has a pervading influence, not only on the cost of construction, but perhaps even more importantly, on the operating and maintenance costs throughout its life. Indeed, it is the design that ultimately determines the effective life of a facility, and the requirements for repairs, renovation or refurbishment during its life. In many if not most construction projects, there is a well–known trade off between the capital cost of construction, and the ongoing maintenance and operating costs throughout the operating life of the facility. Cheaper construction costs, achieved by the selection of less durable materials or less robust equipment, often lead to significantly higher maintenance and operating costs. This issue was brought into sharp focus during the construction of the Channel Tunnel: the consortium of civil engineering contractors who constructed the infrastructure and procured the equipment had a real contractual interest in minimizing the construction costs, whereas the operating entity's interest was in minimizing the life–cycle costs, including the costs of operation and maintenance over many decades. The contractual arrangements did not adequately address those conflicts of interest – there was an ambiguous optimization clause, which required the best balance that could be achieved between capital costs and operating, costs. Inevitably, this resulted in expensive and complex disputes.[5]

The significance of design cost in relation to a project is succinctly encapsulated in the 1:10:100 'rule': 'Over one typical 'life cycle' of a facility, for every one dollar $1 spent on design, at least ten dollars $10 are spent on construction and at least one hundred dollars $100 are spent on OM&R [operation, maintenance and repairs/refurbishment]'.[6]

Thus, whilst design may represent of the order of 10% of the construction cost, it is typically less than 1% of the total life–cycle costs of a facility. Considering the importance of the design function in making the fundamental decisions which will determine not only the constructed cost but also the total life cycle cost, it is clearly of the utmost importance to obtain the best (most appropriate?) design. These relative cost figures indicate that in the overall picture, the cost of design itself is of far less significance than the quality of the design that determines the life cycle costs of the project.

WHO CARRIES OUT DESIGN?

As noted above, design is an intellectual exercise. It is based on the knowledge, experience and skill of the practitioners who carry out the design. All of these three elements are fundamental to the production of designs that are suitable for their purpose. Knowledge is usually gained initially from tertiary education, supplemented by the lifelong learning that is the hallmark of a true professional. Self–evidently, experience is gained from having worked on other projects. The skill arises from the synthesis of the knowledge and experience in a relevant way to the project at hand. It is the quality of this exercise of intellect that ultimately determines the quality of the design. Neither knowledge nor experience alone or in combination is adequate; skill is necessary to produce an appropriate design.

The employer who wishes to build a facility engages a designer to produce the required IP for initial construction, and (possibly) also for the subsequent operation and maintenance. (The term 'employer' is used in this paper to refer to the entity that engages the designer, irrespective of whether the employer is an owner or a design and construct or EPC contractor.) To produce the project IP the designer must draw on his/her own IP in the form of his/her knowledge, experience and skill (personal IP). Typically, an employer will seek to engage the designer who has what is perceived to be the most appropriate personal IP for the project, taking into account such other factors as time and cost. Other things being equal, experience in similar projects is a significant aspect of the required personal IP. An employer would generally prefer to engage a designer who has relevant experience of similar projects over one who, although otherwise apparently equal, has no such experience.

In much of the world, independent professionals in the form of consulting engineers or architects carry out the majority of design. Construction contractors, even major international contractors, do not normally have a large in–house staff of designers for the permanent works, although they may well have in–house designers with particular expertise in the design of the temporary works needed during construction. The barriers to entry for new consultants are few, and there is a wide spectrum of sizes of consulting firms. Recent statistics on the size of consulting engineering firms in Australia show that the industry is predominantly composed of small–scale firms of 1 to 10 people; in 2006 only 6% of total establishments employed more than 20 people, and only 0.3% employed more than 200 people.[7] Thus, notwithstanding the size and capacity of the largest consulting engineers, in Australia at least, small firms of less than 20 people carry out the majority of consulting engineering.

Consulting engineering and architectural practice is based on 'peopleware', and not on significant capital assets. It is often said that a consulting engineer's assets go home every night. The consequence of this is that the bottom line of a consulting engineer's balance sheet is typically comprised of mainly intangible assets that retain their value only whilst the organization is an ongoing entity, able to continue to win consulting assignments in a competitive marketplace. One need only reflect on the rapid collapse of Arthur Andersen in 2002 to realize how a consultant's ability to continue in business is dependent on its reputation, and how ephemeral are the intangible assets of even a large consulting organization.

It is suggested that employers should be very cautious in assessing the financial ability of a consulting engineer to meet contractual obligations based on the balance sheet value of the business. In the event of a major claim against a consulting engineer, the only predictable financial resources available are likely to be the proceeds of professional indemnity insurance. The balance sheet is almost certain to substantially overestimate the value of the business in the event of insolvency, as the intangible assets are unlikely to be realized.

WHAT ARE THE DESIGN RISKS?

It is suggested that, similar to the risks in a construct only contract, design risks can simplistically be considered under the headings of scope, time, cost and quality.

Scope

The extent of the works to be designed, i.e. the scope of the design, is likely to be the biggest single determinant of the cost of design. In a competitive environment where the cost of the design services is a significant factor in selecting a designer, a consulting engineer/architect will minimize fees by tailoring the scope of the design services to deliver precisely what is required by the contract and no more. For the employer, the scope risks are that the designer has not allowed in the design price for completing all of the scope required by the employer. For the designer, the scope risks are that it will be required under the design contract to carry out a greater scope than it will be paid for.

Time

The time taken to prepare the design as well as its cost are usually at the forefront of the employer's considerations in selecting a designer. Most construction projects have significant time constraints, as well as a limited budget. The inherent time risk for the employer is that the design will not be completed on time, thereby delaying construction with an inevitable increase in cost. This risk is particularly acute once a contractor has been appointed and has been given possession of the site; any delay in completing the design which delays construction may have significant cost consequences, out of proportion to the cost of the design delay itself.

The designer's time risk is that it will not complete the design within the time required under the design contract, thereby exposing it to claims for financial loss by the employer. Parliament House Scotland is a well–known example of substantial time and cost overruns in the construction

of a seminal building, significantly contributed to by the time and cost overruns of the design, coupled with 'fast track' construction and a construction management form of contract.[8]

Cost

The risk inherent in the cost of design for the employer is that it will not get the value it is expecting; that may be a consequence of the employer's unreasonable expectations not supported by the provisions of the design contract, or the designer not delivering the value required by the contract.

In a competitive environment for consulting services, competition is likely to have a levelling effect on the cost of design. Although there will be a range of skills and experience among the available designers competent to prepare the design for a particular facility, their basic capabilities are likely to be substantially similar. The employment cost of professionals (the greatest single cost factor) will be based on the prevailing marketplace, and typical overhead costs including office accommodation are likely to be comparable. Designer's fee rates will therefore generally fall within a limited range, however consultants with greater skill and experience may have higher employment costs and may also be able to command a premium for their skill. Higher quality design may therefore entail higher cost.

Conversely, a substantially lower cost design for a defined scope of work may be based on under bidding ('buying the job'), or a lack of appreciation of the work necessary to complete a competent design. The designer who understands least what is required to complete the design to the employer's requirements may submit the minimum tendered cost for design. Whether low design costs result from buying the job or underestimation of the design task, the result is likely to be that the designer faces the prospect of a significant financial loss in completing its design scope. A fixed lump sum contract for design may be legally effective in forcing the designer to complete the design for the agreed price, but where the designer is in a serious loss–making situation because it has under bid or underestimated, the quality of the end product may suffer from lack of resources: inadequate checking to correct mistakes, failure to coordinate designs between different disciplines, or inadequate consideration of what the appropriate design solution should be, to name just a few possibilities. The inevitable result, it is submitted, is that the quality of the design will suffer.

The cost risks for the designer are that it will not be adequately paid for the design it is obliged to carry out under the design contract. This may result from the designer's own underestimation of the design task, an inadequate understanding of its obligations under the design contract, a failure to recognize and claim for scope changes as variations, incompetent personnel who do not possess the appropriate skills, or inadequate supervision and coordination of the design team.

Design quality

It is submitted that, because of the role of the design in determining the aesthetic, functional and economic characteristics of the completed project, the quality of the design is of overarching importance, not only to the employer for whom the design is prepared, but also for the designer in terms of its ongoing reputation and potential liability. The quality risks for both employer and designer are therefore paramount. The design risks for the employer are that the design will not be of the appropriate quality to satisfy its manifold requirements, including aesthetics, functionality, maintainability, operability, and economic performance and design life. The quality risks for the designer include the possibility of liability for damages for poor quality design, and reputational risks that could have severe long–term effects on its ability to win future work in the marketplace.

IP Risk

There is a further risk that needs careful consideration in a design contract: IP risk. The employer's IP risk is that it may suffer delay or additional cost in construction, operation, maintenance, repair or renovation of the facility because of an aspect of IP embedded in the design which it does not have legal title to. One of the designer's IP risks is that, for IP it created for a specific project, it may not retain the right to use that IP in future projects, thereby foregoing future opportunities.

Insolvency

In addition to the 'execution' risks identified above, there is also the risk of the designer's insolvency. Whilst that may normally be a remote risk, if it eventuates it will inevitably have severe consequences for the employer (as well as for the designer itself!). Those consequences for the employer include inevitable delays in appointing another designer and the time taken for that designer to come up to speed, as well as the additional costs for the new designer completing another's unfinished work, and possibly rectifying defects in that work.

FIDIC identified risks

FIDIC have identified the following areas of risk for consulting engineers in all professional services appointments:

(i) the client;

(ii) the fee;

(iii) the scope of services;

(iv) resources; and

(v) professional services agreement.[9]

The client (employer) risk for the designer is summed up as follows: 'If a client fails to perform the project will fail, leading to the risk of non–payment, dispute and counterclaims. This is not in the interests of either the project or any party interested in the project's success'.[10]

Management of these identified design risks by the employer and the designer is covered in the following sections.

WHO SHOULD BEAR THE DESIGN RISKS?

It is generally accepted that the party that can best manage or transfer a risk should be the one to bear that risk under the contract, often referred to as 'fair' risk allocation. This is a good principle to determine the desirable contractual allocation of risk, but it is frequently not followed in practice. In this author's experience, designers are frequently expected to assume risks under a design contract over which they have no control, and have no way of managing.

Furthermore, the principle does not adequately address those risks that are created by the terms of the design contract itself. For example, the imposition of onerous requirements such as inadequate fees or time to prepare the design, or specifying performance requirements that are impossible to achieve in practice. Whilst it could be argued that the rational designer would not or should not enter into such a contract, in the commercial world an employer may have an overwhelming advantage in bargaining power because of its size, and the likelihood that another designer may well accept such onerous terms.

For those risks that relate to the designer's performance of its obligations under the design contract, i.e. to produce the agreed scope of design deliverables on time, for the contract price and to the specified quality, the designer undoubtedly is best placed to, should and usually does manage those risks. However, there are other risks that the employer is in a better position to manage, and which accordingly should be assumed by the employer.

The primary risk that the employer can and should manage is the scope risk. It is the employer that knows what is required of the project, not only its functional and aesthetic requirements, but also what it is prepared to pay for future operations and maintenance. It is the party that must make the decisions on procurement in terms of the contractual arrangements, the form of contract and the time within which the project must be completed.

Although many design contracts are 'bespoke', purpose written for the particular contract by lawyers acting for the employer, in this author's view there is considerable merit in using standard form design contracts which have evolved through the input of personnel experienced in the industry. Such standard form contracts have what is generally perceived as a fair risk allocation, in which the party best able to control and manage risk is the one that assumes that risk under the contract. Two examples of such standard form contracts are the FIDIC Client/Consultant Model Services Agreement (4th ed. 2006) (White Book), and Australian Standard AS 4122. It is submitted that these standard form contracts are a good guide to balanced risk allocation, with due regard to the legitimate interests of both employer and designer.

MANAGING DESIGN RISK BY THE EMPLOYER

For a particular project, one of the important factors in managing design risk is to ensure the appropriate interface between designer and constructor. This interface can occur in a variety of ways contractually, e.g.

- in a traditional 'construct only' construction contract or under other contractual mechanisms such as construction management/ EPCM or project management, the designer and constructor are separately engaged by the employer;
- the designer is engaged by the constructor in a design and build or EPC project delivery; or
- the design team is assembled from individuals employed by various organizations comprising an alliance.

The selection of the form of contract for the design services is likely to be made as part of the employer's overall procurement strategy. Consideration of the best method of procuring the design within the constraints of a specific project is usually a significant factor in that procurement strategy. In some cases there may be no choice of designer, such as a situation where proprietary technology or IP must be used, or there is only one designer who is appropriately qualified.

It is suggested that where an employer wishes to have maximum control over the design, this can best be achieved via a contractual mechanism in which the designer is directly contracted to the employer. Inevitably, where the contractor under a design–build or EPC contract engages the designer, the employer has less control over the design, and arguably its quality. However, such a contract may achieve completion of the project earlier than under a traditional construct only contract,

because of the ability to 'fast track' by overlapping design and construction. A properly managed alliance gives perhaps the greatest control to the employer in regard to quality, as sourcing the individual members of the design team is not confined to a specific design organization.

The employer can manage its scope risk by careful attention to the details of the design contract before it is entered into, and appropriate supervision of the designer during preparation of the design. This includes ensuring that the full scope of the required design is fully and unambiguously defined in the design contract, and that there is a proper mechanism for the issuing and approval of scope variations before they have been implemented. During the design, the employer should monitor completion of the contractually defined deliverables, and insist on compliance with contractual procedures for scope variations.

As with time and quality, the scope of the design task cannot be divorced from a consideration of its cost. Where the scope is clear and well defined, a fixed price will provide certainty for the employer, and leave the risk of managing the design within the price with the designer.

Conversely, where the scope is not well defined, where research or innovation may be necessary, where there are complex requirements that require considerable investigation and consideration of a range of alternatives, it may be impossible to pre–estimate the amount of effort needed. In these situations, a fixed price for design is inappropriate, and a more appropriate fee arrangement is likely to be based on payment for the amount of design work necessary for the actual scope of work.

With the use of appropriate reporting procedures by the designer, the employer can be kept apprised of its financial commitment for the design work carried out, as well as the projected design expenditure over the coming period. In this way, the employer can limit its commitment for design fees by limiting the scope of the design.

Bearing in mind the 1:10:100 'rule' referred to above, the most effective way of an employer ensuring that the life–cycle costs of the project are minimized may well be to have a greater, rather than a lesser scope for the design concept work; the more design work that is done at the conceptual stage in determining the most appropriate form of the project, the more likely it is that adequate consideration will have been given to all of the critical issues that will ultimately determine the life cycle cost of the project.

Another aspect of managing the risk of design services is in the extent to which the designer's scope includes an involvement during construction. Traditionally, the full design services of a consulting engineer included inspections during construction to ensure that the design intent was met. Many employers still recognize that this is an important function in ensuring quality of the finally constructed design. Where the designer is engaged directly by the employer this is unproblematic. However, in a design and construct contract where the designer's scope is fixed by the contractor, it may be necessary to include a contractual requirement for some form of formal designer's certification, to ensure that the contractor maintains adequate designer involvement during the construction phase.

This is particularly important in those situations in which the

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erection itself is a critical design condition, such as the erection of long span bridges.

This issue was emphasized by the Committee of Inquiry into the failure of the Milford Haven Bridge in 1971, which noted in its final recommendations on contractual procedures:

The engineer should carefully watch the progress of construction to ensure compliance with the agreed erection method; he should scrutinise the contractor's site staff and where necessary exercise his powers under the contract.[11]

Although that recommendation was made over 30 years ago, it is submitted that it as pertinent today as when it was made.

There are limits to the extent to which the employer can manage the time risks. The normal contractual mechanisms of requiring a programme of works which must be kept up to date and regularly reported on (similar to that used in a construction contract) will at least give the employer early warning of time problems. In the event of schedule slippage the employer can implement appropriate contractual mechanisms such as requiring acceleration or a 'show cause' notice, if these are provided for in the design contract. Milestone payment mechanisms may also provide a powerful financial incentive for a designer to perform to an agreed timetable.

Managing the quality risks of design is perhaps the most challenging of all for the employer. Typically, the employer engages the designer because it does not have the appropriate design skills itself. It may not have sufficient technical skills to adequately address the quality of the design being prepared. It is suggested that an employer can nevertheless minimize its design risks by:

- careful selection of the designer, based on its proven knowledge, experience and skill, and an assessment of its capability to design the particular facility to the required quality within the defined time;
- requiring the designer to have adequate internal procedures for checking the quality of the design against the contractual requirements;
- auditing the designer's internal procedures to ensure that the design checking has been carried out in accordance with the defined procedures; and
- appointing a checking or 'proof engineer' where independent assurance of design quality is deemed to be appropriate.

It should be noted that each of these actions may have cost consequences for the employer. It is specifically not suggested that the cost of design should be a primary basis for the selection of designer, as this is likely to run counter to the selection of the designer who will produce the required design quality. A consultant with a sophisticated quality assurance system, particularly one certified to the requirements of ISO 9000, will inevitably have a higher cost structure than one that relies on ad hoc checking. Similarly, the cost structure of a single person design company will be much less than that of a company employing tens or hundreds of qualified people; it would be naive to assume that such disparate organizations were in any way comparable in their ability to produce quality checked designs.

Auditing of the designer's internal quality procedures, and appointing a proof engineer have an obvious cost for the employer. However, they will significantly decrease the risks that the design is not of the required quality. Bearing in mind the 1:10:100 'rule', the additional cost spent during the design phase is 'insurance' that the life cycle costs will be minimized because the design has been prepared to the appropriate quality.

The employer can manage its IP risk by appropriate warranties, indemnities and undertakings in the design contract. It will require an indemnity from the designer for any breach of any other party's IP by the designer. As the entity paying for the design, the employer would normally expect to receive as part of that design all of the IP required to construct, operate, maintain, renovate, alter or demolish the facility as it sees fit, without payment of additional cost over that agreed to in the design contract. It is submitted that, in the majority of construction contracts, the employer will manage those IP risks appropriately by ensuring that it has a royalty free, irrevocable license to use the IP in connection with the facility for any purpose during its life; it would not normally be necessary to require a complete assignment of all IP by the designer to the employer.

The issue of moral rights in connection with the design may need separate consideration in respect to designs in which aesthetics play a large part, such as seminal buildings. A world leading designer may be reluctant to surrender some of its legally protected moral rights, such as for attribution of authorship or right of integrity; in such cases a mutually acceptable sharing of IP risk will need to be negotiated.

There are limits to the ability of an employer to manage the risk of a designer's insolvency, as this may be triggered by events over which the employer has no influence. An employer should carry out appropriate due diligence on the designer's Professional Indemnity (PI) insurance and financial

strength before the design contract is entered into. A financially strong designer that maintains its commercial viability and PI insurance is likely to be in the best position to satisfy any liability for damages.

However, as outlined above, the balance sheet assets of most consulting engineers are confined to intangible assets that will quickly dissipate in the event of insolvency. Their ability to meet a claim for damages is often confined to the PI insurance they carry.

It is submitted that it is ultimately not in the employer's interest to insist on contractual terms which might have the effect of jeopardizing the coverage or existence of the designer's PI insurance. Further, whilst properly drawn up contractual warranties are undoubtedly legally enforceable, to the extent that they are not supported by the terms of an appropriate insurance policy, the designer may have inadequate financial resources to meet any liability for damages.

MANAGING DESIGN RISK BY THE DESIGNER

The threshold issue for the designer's risk management is due diligence on the employer, to ensure it is competent to procure the project and pay for it. No matter how attractive the project, a designer takes on unquantifiable and unmanageable risk if it cannot be reasonably sure that the employer has the ability to complete the project and pay the designer's fees when they fall due.

Once satisfied of the employer's bona fides, the designer should ensure that the conditions of the design contract:

- define the scope of the design required clearly and unambiguously, both in relation to the extent of the work, as well as the quality standards it must comply with;
- provides for adequate payment for the required scope of work;
- provides sufficient time for completing the scope of work to the required quality, including the necessary checking;
- does not require the designer to undertake contractual risks over which it has no control and cannot obtain insurance for; and
- does not contain terms that might impact its ability to carry out similar work in the future.

Many designers will see this as a counsel of perfection, unachievable in the real commercial world where typically the employer has considerably greater bargaining power, and the option of choosing another designer who may not object to one–sided contract terms. Nevertheless, each of these issues involves real financial risk to a designer, and is ignored at its peril. They cover managing the FIDIC risks (ii), (iii) and (v) above.

The first three bullet points above have already been discussed, and are sufficiently obvious that they are likely to be at the forefront of a designer's mind in negotiating a design contract. In relation to contractual risks over which they have no control and cannot contain insurance for, designers may be requested under a proposed contract to:

- take responsibility for information provided by others and which cannot be verified;
- provide a fitness for purpose warranty;
- provide an unqualified warranty to maintain PI insurance for an extended period of time, perhaps up to 12 years; or
- provide PI insurance of an unlimited amount.

The best way of the designer to manage the risks arising from such onerous terms is to ensure that it does not commit to them in the design contract. Designers are aware that their PI insurance is generally confined to covering their liability for a failure to take reasonable care (and in Australia for misleading or deceptive conduct in breach of the Australian Consumer Law), and do not cover breaches of contractual warranties which do not involve a failure to take reasonable care. Thus, any liability for breaches of such contractual warranties must be met from the designer's own financial resources, and not from PI insurance. To the extent that the designer cannot negotiate such terms out of the design contract, it takes on an uninsurable financial risk that, if it eventuated, could have severe commercial consequences.

Designers are well aware that PI insurance is expensive, it is generally issued on an annual basis, it responds only to claims or alerts made during the policy year, and is for an agreed and limited amount. The ability to obtain PI insurance in subsequent years depends upon such insurance being available on reasonable commercial terms, the designer not being refused insurance because of a poor claims history, and ongoing operations of the designer which generate sufficient revenue to pay the insurance premiums on an annual basis. An unqualified warranty to maintain such insurance for a number of years in the future entails a commercial risk for the designer. The most that should reasonably be expected from a designer is that it will make best endeavours to maintain insurance for the required period, provided it is available on commercial terms.

Once committed to the terms of a design contract, a designer best manages its execution risks by fulfilling its obligations in accordance with the requirements of the design contract. This

usually entails proper internal management of the design teams: adequate resourcing at the 'coalface', proper planning, supervision and coordination, reporting to the employer on a regular basis, appropriate checking and quality assurance, and provision of the required deliverables on time—all issues related to managing the resources risk (iv) above identified by FIDIC.

These are all issues that are very familiar to every competent designer; in any organization with a quality system certified to ISO 9000 there are usually detailed procedures that define a systematic and auditable process for delivering a quality product. An employer should be able to rely on a designer complying with its procedures. Any departure from them entails increased risk for the designer.

CONCLUSION

This paper has endeavoured to identify the major design risks in a construction project, generally under the headings of scope, time, cost and quality. The fundamental importance of design in achieving a project that satisfies the manifold requirements of aesthetics, functionality, constructability, operability, maintainability and economic performance over its life cycle has been emphasized.

The 1:10:100 'rule' brings into sharp focus the impact that design decisions made at the earliest stage of a project have on the ultimate outcome over its life. The corollary to this 'rule' is that the most effective investment in ensuring project success is that made to obtain the most appropriate design. A 'better' design, even if it costs more to produce, can reap substantial financial returns over a long period of time in the form of lower operating or maintenance costs, or a reduced requirement for upgrading or refurbishment.

The employer can manage its design risks by appropriate selection of the right designer, agreeing to reasonable and equitable terms in the design contract which protect the employer's interests without an unreasonable or unrealistic shifting of risks to the designer, and by agreeing to reasonable remuneration and time to perform an agreed scope of work to the required quality. In addition to auditing of the designer's compliance with the requirements of the contract, in appropriate cases it may be appropriate to engage an independent 'proof engineer' to ensure the quality of the design. The employer's best risk management will be to have an unrelenting focus on the quality of the design, and provide an appropriate contractual setting in which this has the best opportunity of being achieved.

The designer can best manage its design risks by appropriate due diligence on the employer, by not agreeing to contractual terms which place unmanageable and uninsurable risks on it, by ensuring that it will be adequately remunerated for a clear and unambiguously defined scope of work it is required to execute, and by executing that scope of work in accordance with the contractual requirements. Managing risks during execution of the design requires that adequate attention be given to resources, not only those at the 'coalface' but also those required for supervision, coordination and checking. Quality certified design organizations generally have sophisticated procedures intended to achieve designs to the appropriate quality, delivered on time with an acceptable financial outcome. A designer ignores those procedures at its risk!

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