

DESIGN AND DOCUMENTATION DEFICIENCY AND ITS IMPACT ON STEEL CONSTRUCTION

P. A. Tilley
CSIRO - DBCE

1. INTRODUCTION

The Australian construction industry has been portrayed by industry analysts as being uncompetitive and inefficient, with current design and documentation quality being of major concern to many parties within the industry [1]. As design and documentation quality has a major influence on the overall performance of construction projects [2,3,4], any improvement in quality should lead to corresponding improvements in the efficiency of the construction process. Designers provide the graphic and written representations that allow head contractors and trade contractors to transform concepts and ideas into physical reality. How effectively and efficiently this transformation occurs, depends largely on the quality of the design and documentation provided. Inadequate design and documentation leads directly to delays, rework and variations – contributing to increases in project time and cost – and indirectly to increases in the workload of project personnel, adversely affecting their ability to perform effectively and efficiently [5].

Recently, the CSIRO has undertaken an investigation into the causes of design and documentation deficiency and its effect on the efficiency of the construction process. Early in 1997, the CSIRO organised two industry workshops – one for designers and one for contractors – to obtain industry opinion on the main factors affecting design and documentation quality and the most significant effects of design and documentation deficiency. These industry workshops considered many issues on the matter and were not steel specific. Soon after, the AISC arranged a special steel industry forum also dealing with the issue of design and documentation deficiency, but emphasising its effect on the production of structural steel. This paper outlines the overall aims of the CSIRO study and highlights the outcomes from the two workshops and the steel industry forum. The main factors affecting design and documentation quality, as well as the most significant effects of design and documentation deficiency – as seen by the participants of the three industry gatherings – are identified. Approaches to minimise design and documentation deficiency and improve overall construction process efficiency are also proposed.

2. BACKGROUND

Anecdotal evidence in Australia suggests that a reduction in project design fees over the past 10–15 years, has had a major bearing on a claimed decrease in the quality of design and documentation being supplied to contractors. It is also claimed that this decline in quality has also lead to a corresponding reduction in construction process efficiency – indicated by increased levels of contractor *requests for information* (RFIs), design changes, design coordination problems, variations, rework and increased project administration.

Of major concern to the industry, is the extent to which poor coordination and design is contributing to the problem of rework and rectification. When considering the problem of rework, [6] notes that a large proportion of rework and non-conformance costs are due to deficiencies in design and documentation and in the transfer of information during the design process. Whilst site issues such as inadequate construction planning, defective workmanship,

product defects and coordination failures also add to the rework problem, Love *et al* feel that the source of the problem goes deeper into the way that the industry operates.

In researching the literature on rework, [6] found it to be a chronic problem in the construction industry all over the world – citing examples from Belgium, Sweden, the USA and Australia – and that a large proportion the rework was due to deficiencies in design and documentation. Although the direct costs of rework ranged from 4% to 20% of total project costs, the total cost of rework was considered to be much higher, due to *‘the impact costs associated with rework and lack of quality management’*. According to [6], it appears that the costs of rework are being accepted as a normal part of the project procurement process. It appears unusual, that neither clients nor contractors appear to realise the huge opportunities to reduce project costs, if rework could be reduced or eliminated.

Similarly, [7] also found that problems with design and documentation quality and the communication of design information were major contributors to rework and rectification. They also indicated that the cost of rework went beyond just the direct physical cost of rectification. Some of the problems identified as being associated with rework and rectification included lost time, reduced employee morale, reduced safety standards and reduced worker efficiency; all of which led to *“a reduction in project team performance”*.

When considering the issue of designing for minimum cost, [7] indicated that designers often overlook the fact that the most economical structure is not always determined by minimum material costs. Other factors relating to the ease of fabrication and erection also need to be considered. By directly considering these types of factors, designers have the ability to directly reduce the levels of rework and improve project quality and performance.

According to [8], overall project quality is greatly determined by the level of professional services provided. How these services are selected and how the fees are negotiated however, generally determines the quality and extent of the services provided. Where designers are selected solely on the basis of low design fees, then the level and quality of the service provided is likely to be limited. This translates into additional project costs for both the contractors and the owner.

In a study of the relationship between fee structure and design deficiency, [9] showed that design deficiency had a non-linear, inverse relationship with project design fees. The study also showed that when design fees were reduced below their optimal level, project costs increased sharply due to increases in design deficiency. [10] also noted that as design input decreases below the optimum, total project costs increase. Similarly, the concept of reducing total project costs by increasing expenditure on the design process has been well documented through the principles of *value engineering* (VE) [11] and *value management* (VM) [12]. As with all things, when procuring design services, *you get what you pay for*.

But what is design and documentation quality? Although highly subjective and open to interpretation, [10] stated: *“a good design will be effective (ie, serve the purpose for which it was intended) and constructible with the best possible economy and safety.”* But whilst the design itself needs to be “effective”, it also needs to be communicated effectively through the documentation (*ie*, drawings, specifications, *etc*). When documentation quality is considered, a number of criteria determine the level of quality [13]:

- timeliness – being supplied when required, so as to avoid delays;

- accuracy – free of errors, conflicts and inconsistencies;
- completeness – providing all the information required;
- coordination – thorough coordination between design disciplines; and
- conformance – meeting the requirements of performance standards and statutory regulations.

Based on these criteria, the quality of the design and documentation process can simply be defined as “*The ability to provide the contractor with all the information needed to enable construction to be carried out as required, efficiently and without hindrance*” [13]. Unfortunately, contractors are at times supplied with project documentation, which is considered to be sub-standard or deficient due to incomplete, conflicting or erroneous information, necessitating revisions and clarifications to be provided by the designers. What is of most concern however, are the claims that the incidences of sub-standard or deficient design and documentation being provided, has been continually increasing over the past 10 to 15 years. It should be noted that these problems are not specifically contained within the steel construction industry.

Although a recent Australian survey confirmed that poor design and documentation quality was a major cause of construction process inefficiency [14], there appears to be no formal evidence in Australia to link this to a reduction in overall design fees over the same period. Whether or not a causal relationship between reduced design fees and construction process inefficiency can be proven, it is felt that the identification of the causes of reduced design and documentation quality would be the first step in eliminating these problems and improving overall construction process efficiency.

3. INDUSTRY SURVEY

To determine whether or not such a casual relationship exists, CSIRO has instigated a national industry survey of designers, main contractors and trade contractors, aimed at investigating not only the causes and effects of design and documentation deficiency, but also the extent to which design and documentation quality has changed over the past 10 to 15 years. To accomplish this task, the survey proposes to examine the changes within the building construction industry over the past 10 to 15 years in:

- the level of design fees being obtained
- the level of the design and documentation quality
- the workload of construction process personnel
- the level of information and communication flows, and
- the level of design changes, variations and levels of rework.

Due to the time period under investigation (10 to 15 years), it is expected that the data collected will be mainly subjective and based on the respondents’ perceptions of the problems and the changes experienced. It is hoped, however, that more substantial ‘historical’ evidence will also be obtained.

4. INDUSTRY WORKSHOPS

To ensure that the national industry survey addressed only pertinent issues, two industry workshops – one for contractors and one for design professionals – were undertaken as part of the background investigation stage of the study. These workshops – designed to obtain a

cross-section of up to date industry opinion on the issues identified – generated tremendous interest and support from industry associations and the design professions.

Although the relatively small number of participants in the workshops preclude any definitive conclusions being made, the outcomes are still considered to be of significant importance to the success of the study. They have provided valuable industry information that has been used to develop the survey questionnaires, which will fully investigate and hopefully quantify the problems experienced by contractors and construction professionals, in relation to the perceived deficiencies in the design/documentation process.

The workshops were conducted using a modified nominal group technique (NGT) process [15] to highlight and prioritise the issues raised by the participants. NGT workshops are typically of two hours duration and are particularly useful when seeking input from people across a broad range of rank and position in organisational structures. NGT is a facilitated process, which begins by clarifying the problem being addressed and then asking each person participating in the workshop to work silently, generating ideas in response to a specific question or statement.

In the modified form of NGT used in these workshops, participants (12–25) work in pairs or groups of three, where each pair or group creates one list of items representing their collective input. A round-robin session then collects all ideas from the workshop participants as a whole. This round-robin process continues until all ideas have been recorded, including additional ideas that occur to people as the round robin is in progress. Each idea is briefly discussed by the group as a whole, prior to ranking the significant items.

The ranking process is also carried out in pairs or groups of three and involves selecting from the whole list of ideas (typically 40–60) those that are seen to be particularly significant. Each pair or group is then asked to select seven items and place them in order of perceived significance (ie. 1 being the least significant and 7 being the most significant). The results of this process are then recorded and the group as a whole is able to develop a consensus view of the situation being addressed. The NGT process is used extensively in conducting workshops where the purpose is to identify a number of key ideas or issues and to gain a group consensus of priority and significance. Based on the information gained from these workshops, questionnaires specifically directed at the design consultants, contractors and subcontractors can be developed.

5. CONTRACTORS' WORKSHOP

5.1 General

Initial invitations were sent out, via industry associations, to the top 100 commercial building companies. Through expressions of interest and follow-up phone calls, 19 people indicated they would attend the workshop. Of these 19 people, only 12 people, representing a wide cross-section of the industry, actually participated in the workshop. Using the NGT process, these people were then organised into five groups to determine the responses to the following question:

*'Please take a few moments to write down in the spaces below, any specific problems that you personally experience with **design and documentation** supplied for building projects.'*

Although a total of 40 responses were provided by the participants, not all responses were rated when the groups were asked to select what they considered to be the seven most significant. Table 1 provides a list of only those responses for which a level of significance was indicated and also provides the rankings given to each response.

As can be seen from the outcomes shown in Table 1, the process identified two overall main issues of concern to the participants. These are:

1. *Insufficient coordination between design disciplines.* This issue, which was indicated as being the most significant by all groups, was seen as having a major impact on the efficiency of the construction process.
2. *The extent and adequacy of details and design generally.* The groups felt that the extent and adequacy of the design and the details included within the documentation provided were generally insufficient to allow work to proceed efficiently.

As an example of the detail design problem, one participant offered the following quote from a Gold Coast design firm: “We don’t supply details, until we are asked to.”

5.2 Effects on Construction Process Efficiency

Having identified the main problems experienced with design and documentation, the participants were then asked to think about the effects that these two main issues had on the efficiency of the construction process. Based on the responses received, the view of the participants was that poor quality design and documentation leads directly to:

- inefficiencies in the construction process
- increased contractual and litigation risk
- increased costs to both the builder and the client, and
- increased potential for reduced quality of the completed project.

5.3 Changes in the Last 10–15 Years

To try to assess the effect of time on the issues identified, the participants were also asked to think about the changes to the industry and the levels of design and documentation quality that they have seen over the past 10–15 years. Based on the responses received, the view of the participants was that:

- the quality of design and documentation has declined over this period
- due to a reduction in design fees, design firms were reducing the level of service they provide, and
- due to a reduction in design fees, design firms were using a greater proportion of junior and inexperienced staff for more senior functions.

5.4 Summary

To finalise the workshop, the participants were asked to think about the issues raised during the workshop and consider what they thought to be the outcomes. Based on the responses

received, the view of the participants was that there is a major problem with the current design and documentation process and that it manifests itself as:

- a lack of design coordination
- insufficient or inadequate design detailing, and
- reduced design and documentation quality.

As a consequence, the participants felt that these problems have not only led to inefficiencies in the construction process but also to increases in overall project costs.

6. DESIGNERS' WORKSHOP

6.1 General

Initial invitations were again sent out, via industry associations, to the various design disciplines. Through expressions of interest and follow-up phone calls, 31 people indicated they would attend the workshop. Of these 31 people, 25 people, representing a wide cross-section of the design industry, actually participated in the workshop. Using the NGT process, these people were organised into 10 groups to determine the responses to the following question:

*'Please take a few moments to write down in the spaces below, any specific problems that you personally experience in the overall **design and documentation process**.'*

In this workshop, the participants provided a total of 46 responses. Again, as not all responses were ranked, Table 2 only provides a list of those responses for which a level of significance was indicated, along with the rankings given to each response.

The outcomes of the process, identified four main issues of major concern to the participants. These are:

1. *Overall low fee structures, unpaid work and a lack of profits.* This issue was further discussed, with the following effects on the design process, being noted -
 - insufficient personnel to do the work, causing an overload on those available
 - greater use of junior and inexperienced staff to do the work
 - reduced quality of the service being provided
 - reduced levels of in-house training, and
 - reduced levels of research and development.
2. *Insufficient overall design time.* This issue was specifically discussed further, as the context in which the issue was raised was felt to be a little unclear. To ensure that the responses were interpreted correctly, the participants were asked to clarify what they meant when referring to time. Discussions about the points raised by the participants indicated the following two main issues in regard to time -
 - due to insufficient fees being offered and accepted by consultants, there was insufficient paid time to provide the service considered necessary; and

- irrespective of the fees paid, the ever-decreasing time allocated for the design function has meant that there is insufficient time to properly consider potentially cost-effective alternative design solutions.

The participants felt that due to a combination of these two issues, the clients – by their own actions – were not getting the service that their projects required, and that this was leading to inefficiencies and additional project costs.

3. *Inadequacy, changeability or uncertainty of the client/design brief.* This issue was also further discussed, with the following effects on the design process being noted -

- design rework due to misinterpretation of client requirements
- design rework due to changes in client requirements, and
- design services contracted being incompatible with overall project requirements.

4. *Unrealistic client expectations, including the need to educate clients on value of comprehensive and clear documentation and Bills of Quantities, and the need for compatibility of design services provided by the consultant team.* Again, this issue was further discussed, with the following effects being noted -

- high levels of client dissatisfaction
- projects not being completed to budgeted time and cost, and
- increased levels of variations and rework due to insufficient documentation and coordination.

The workshop participants saw all of these four main issues as having a dramatic and adverse impact on the way that the processes of design and construction are carried out.

6.2 Changes in the Last 10–15 Years

As in the contractors' workshop, the participants were asked to think about the changes they have seen over the past 10–15 years to the way design and documentation processes are carried out. Based on the responses received, the view of the participants was that:

- industry deregulation and an unfavourable economic climate over the past 10–15 years had increased the level of competition for an overall reduced amount of work available
- with an increased level of competition came a reduction in the level of fees being required to win the work available
- with the reduction in fees came a reduction in the services provided, and
- as a consequence of the above, the design function has been downgraded or devalued from a client perspective.

6.3 Summary

To finalise the workshop, the participants were asked to think about the issues raised and consider what they thought to be the outcomes. Based on the responses received, the view of the participants was that the following issues needed to be addressed if improvements to design and documentation quality and construction process efficiency, are to be achieved:

- increases in the fees paid to design consultants, to allow an increase in the level of service provided
- assistance to clients to help them understand the time and effort required to provide a quality service for any particular project, and
- assistance to clients to help them formulate a detailed and definitive design brief at the start of the project, so as to avoid any unnecessary changes later on.

7. AISC INDUSTRY FORUM

7.1 General

An AISC industry forum was organised in Brisbane during 1997 specifically to highlight the typical problem areas occurring in the industry, as a result of poor engineering documentation. This forum was somewhat similar to forums organised by AISC in other regions of Australia. In contrast to the industry workshops, the format for the forum was such that three industry representatives – a structural engineer, a steel detailer and a steel fabricator – were invited to provide short presentations on the issues. In their presentations they were to discuss the issues from their individual perspective and through audience discussion, seek to determine possible solutions to a problem which is seen as reducing the efficiency of the steel construction industry.

Initial invitations were sent out, via an industry mail-out, to a wide cross section of AISC members. Possibly due to the topical nature of the issues to be addressed at the forum, 145 people indicated they would attend. Of these 145 people, approximately 110 people, representing all sections of the industry, actually attended and participated in the forum.

It should be noted here that the author's role at the forum was only that of an observer and not as a participant. As such, the forum outcomes presented here are solely based on the author's interpretation of the presentations given and the discussions that followed.

7.2 Structural Engineer's Perspective

A prominent consulting structural engineer from Brisbane was the first presenter. Not unexpectedly, and in line with the outcomes of the designer's workshop, reductions to the levels of design fees were identified as being a major contributing factor to the limited levels of documentation being produced. The speaker mentioned that reduced design fees limits the time available to design and document projects though it is not an option to simply leave a portion of the details out the documentation.

The presenter expressed the view that his company's documentation was not poor – indeed they may provide too much detail - though he left it to other speakers to give their views on the matter. Possibly as a response to the reductions in design fees, the presenter indicated the following concepts as part of their, and other consultants, approach to providing economical structural design documentation irrespective of fees:

- aim to *provide sufficient* information to the steel detailer to enable the project to be constructed
- minimise or exclude details, which can be determined by the steel detailer – e.g. non-critical bolt locations, galvanising requirements (e.g. drain holes, etc.), etc.

- use standard member and connection details where possible, to minimise documentation *and fabrication* costs
- do not provide design details which are mirrored in architectural drawings
- as a general rule it is more effective to use more steel and simplify connections for both documentation and fabrication
- try to minimise variations and complications to details as these add to documentation time and fabrication costs
- a publication worth referring to is the AISC guide for engineering drawings of structural steelwork [1] which sets out acceptable documentation standards
- it is important that the engineering framing solution and associated details are in keeping with the architectural requirements to reduce confusion and wasted time by the steel detailer in resolving conflicting information
- the engineer should have an adequate knowledge of fabrication requirements to ensure what is documented can be economically procured, fabricated, surface treated, transported and erected.

The presenter then commented on economical aspects of welding, bolting, galvanising, transportation and erection of structural steelwork.

In concluding the presenter suggested that in the documentation phase design engineers should think through the constructional aspects of the building and effect details in a similar order. Guidance may be given to the architect to achieve a cost effective solution though this should not be done to limit their flair.

7.3 Steel Detailer's Perspective

A prominent steel detailer from Brisbane was the second presenter. The presenter indicated that his role was to provide a steel detailer's view of engineering documentation and that he was very concerned with the current level of design and documentation quality. As steel detailers were responsible for the process of interpreting architectural/structural design information and converting it into details suitable for fabrication, the presenter considered this to be a critical part of the process associated with steel construction.

In accordance with the outcomes of the contractor's workshop, the presenter noted that he felt that the quality of engineering details provided over last 10 years has decreased. He also felt that the problems of design and documentation quality were primarily due to reducing fee structures and that these problems were directly contributing to increased project costs, due to:

- engineers "economising" and not providing sufficient details – particularly difficult or specialised details
- engineers providing unworkable/impractical details, and
- engineers wasting time by only providing standard details.

The presenter noted that the lack of adequate information on engineering drawings was more noticeable on light industrial and commercial projects than on heavy industrial projects. It was also the presenter's opinion that it was not unreasonable for steel detailer's to expect that the quality of documentation supplied by the engineer to the detailer was at least the equivalent of that provided to the fabricator by the detailer.

To ensure the efficiency of the construction process, the design and documentation process also needs to be economical and efficient. According to the presenter, the AISC guide for engineering drawings of structural steelwork [1] was the end result of due concerns from fabricators with regard to the quality of engineering drawings. Using excerpts from the guide, the presenter noted that the cost impact of incomplete engineering documentation can include:

- significant increases to steel detailing costs
- increased tender prices due to the uncertainty which results from lack of detail
- unnecessary correspondence and time wasting communication
- time delays due to a need for clarification of details, and
- excessive delays in the preparation of shop drawings.

When considering the types of problem areas encountered in engineering drawings, the presenter noted the following as being the most typical:

- lack of detail
- conflicting details
- neglecting difficult details, and
- poor and erroneous cross-referencing.

On some projects, the presenter noted problems of:

- impractical details being shown
- insufficient attention to problem areas or lots of detail missing

with the problem getting bigger. Some engineers were noted as having insufficient knowledge of detail design whilst others were supplying details which indicated insufficient thought being given to constructability issues. In both situations, inexperience was indicated as the likely cause. The presenter complained that in his opinion, steel detailers were becoming a checking service for engineers.

In summing up, the presenter noted that the major impact of engineering design and documentation deficiencies on the shop detailing of a project included:

- time delays (often weeks), waiting for information clarifications (RFIs) caused by inadequate or impractical design details
- increased costs due to time delays causing inefficiencies, and
- increased costs due to increased levels of correspondence – ie. 100's of RFIs at a significant cost per RFI.

According to the presenter, appropriate design details need not cost more. Careful planning, an understanding of what information is required and minimisation of duplication of information can reduce time spent in engineering documentation.

7.4 Steel Fabricator's Perspective

A prominent steel fabricator from Brisbane was the final presenter. Although the presenter indicated he was concerned with the current level of design and documentation quality, he also felt that detailing had been the greatest advance in the fabrication industry. As

fabricator's base costs and estimates were usually based on only a limited set of engineer's drawings – very rarely do fabricators have architect's drawings as well – fabricators were accepting the costs for detailing in order to try to find savings in the project costs.

In the presenter's opinion, the quality of engineering drawings/documentation has deteriorated over the years and there appears to be no one coordinating the design process. Specifications and standard notes are generally not project specific and when specific issues are provided, they tended to be hidden in standard conditions and notes. As a result of this, the sub-contractors – although not getting paid for it – end up doing the design work for the architects and engineers and end up bearing the risk.

According to the presenter, fabricators cannot afford to allow for documentation deficiencies. If a fabricator did allow for all the costs involved with RFIs, delays and coordination problems, they would be unlikely to win any jobs. As has occurred with the presenter, this has caused fabricators to incur major additional costs, not just due to the delay and disruption caused by documentation deficiencies, but also in the issuing and processing of RFIs. As an example of the severity of the problem, the presenter cited a project where thirty RFIs were required to be issued in 16 days, due to insufficient detail being provided. It was also noted that unfortunately, these costs are often unrecoverable. The presenter noted that steel is often constructed whilst waiting for shop drawing approval by the engineers. This is obviously done to try to meet the contractual time requirements of the builder, as the completion dates for the fabricator do not change due to documentation deficiencies. If however the shop drawings are not approved or require modification, extra costs are then incurred due to the required redesign and rework.

According to the presenter, the problem lies in the fact that engineers have no responsibility to the fabricators and therefore don't have the same concern about answering queries promptly. Builders, on the other hand, are trying to reduce their responsibility by getting the fabricators to sort out the problems. Fabricators do however have to bear some of the responsibility for the problem, as according to the presenter, many fail to look closely at the details when pricing a job.

7.5 General group discussion and comments

Following the three presenters, there was a period of time provided for the audience to question or comment on the previous presentations. The following provides some brief conclusions to the issues raised, based on the discussions that occurred during this period:

- design quality is fee driven and due to time constraints the design process is no longer phased but is under constant evolution
- CAD decreases the quality of the information on the drawings, due to poor cross-referencing and ease of changing the drawing without properly assessing the impact of the changes on other parts of the drawing(s)
- *the effects of poor documentation were increased levels of RFIs and other administrative correspondence. This issue led to a hypothetical, yet interesting discussion on how an engineer could – from a purely commercial position – determine a project bid based on savings accrued from reduced levels of design service and quality, being only partially offset by the expected increase in administrative costs.*
- detailers were starting to get contracted by engineering firms to produce details

- the appears to be an increasing problem of ethics in engineering, with engineers being pressured by developers and builders for low cost/poor quality documentation
- the major problems with fast tracking are additional rework and extra costs to the contractors
- detailers are starting to load costs for particular engineers and were advising the fabricators and builders accordingly
- more effort is required in the checking of engineering drawings prior to them going out of the office
- errors in detailing/shop drawings start when workers become frustrated with poor engineering design details, and
- the quality of fabricator's work can also diminish when poor engineering design details are supplied.

8. INDUSTRY SURVEY – AN UPDATE

The valuable industry perceptions obtained from the two workshops and the steel construction industry forum have been used to develop two survey questionnaires – one specifically for designers and another for contactors and trade contractors. These questionnaires aim to fully investigate the primary causes of design and documentation deficiency, and quantify both the extent of associated downstream problems and their effect on the efficiency of the construction process.

At the time of writing, the designer's questionnaire has been completed and due to the assistance of the various industry associations, has been distributed to just under 3000 design and related consultancy firms nationally. The questionnaire was sent to architects, engineers, landscape architects, quantity surveyors and land surveyors and after six weeks, has achieved an overall response rate of just under 14%. Figure 1 provides a brief breakdown of the number of responses received by discipline and indicates how those figures compare as a percentage of the number of documents distributed.

Whilst the designer's questionnaire is currently out with industry, the contractor's questionnaire is undergoing final development and checking from industry partners. Based on current progress, it is hoped that this questionnaire will be ready for distribution by the end of March 1998. When distributed, it is expected that the level of response achieved from contractors will at least match the level provided by the designers.

9. CONCLUSIONS AND RECOMMENDATIONS

The outcomes of both the two workshops and the steel industry forum indicate that all sections of the industry agree that there are major problems with the design and documentation process in the Australian construction industry, and that these problems are leading to construction inefficiencies and increased project costs.

From a contractor's perspective, the deficiencies occurring in design and documentation being provided by consultants, have been steadily increasing over the past 10–15 years and are causing corresponding increases in the extent of inefficiency within the construction process. As a consequence, decreases in project quality and increases in overall project costs result. Of major concern are the additional costs – which to a large degree end up being absorbed by contractors – caused by the delays and disruption in trying to clarify inadequate, impractical, conflicting or ambiguous design and specification documentation.

The designers, whilst also acknowledging this reduction in design and documentation quality and the services being provided, consider the primary causes to be reducing design fees, decreasing project design and delivery times, and an increasing number of clients with unrealistic expectations and an inability to properly define project objectives and requirements. Based on the outcomes of the steel industry forum, it would appear that a number of engineers are working towards the concept of “*performance based design*”, where depending on the type of construction contract used, the contractor and his trade contractors become ultimately responsible for detail design. By getting steel fabricators and their detailers to determine the design details, the engineer reduces his/her detail design responsibility to that of checking drawings only.

In order to reduce the impact of the tight time frames being allowed for design and documentation, it is considered that some designers may be deliberately providing documentation that they know to be incomplete, knowing that the contractor will pick up the deficiencies during construction and raise the appropriate correspondence – ie RFIs. Although this would effectively give the consultant more time to fully consider the project’s design requirements, it provides an unnecessary cost burden on the project and the various participants affected.

Although the clients and developers were likely to benefit most from improvements to construction process efficiency, some workshop participants indicated that a large number of these clients and developers were not interested in improving the construction process and providing a quality product, but were only looking for quick profits. Due to the cost sensitivity of initial feasibility studies, the concept of spending more during the planning and design stages to minimise overall project costs, may be difficult to sell to clients such as these.

The results of the three industry gatherings would appear to indicate that to help minimise design and documentation deficiency, a system which recognises the added value and reduced project costs which come from selecting consultants based on their experience and expertise, should be adopted by all clients. Use of a well recognised approach, such as ‘qualification-based selection’ (QBS) [8], which considers the competencies of consultants as more important than their cost, is proposed as a way to minimise design and documentation deficiency and improve the efficiency of the construction process. According to the Association of Consulting Engineers Australia [16], procuring design services using a QBS system enables cost-saving innovations to be properly assessed and allows for optimal project performance to be achieved.

In relation to the steel fabrication sector of the construction industry, it is the author’s opinion that in order to minimise the risks involved with poor engineering documentation, fabricators should where possible, try to contract out of doing the detailing and providing workshop drawings. By contracting for steel supply and fabrication only, they minimise their risk and ensure that any and all delays and extra costs incurred due to design and documentation deficiencies, are fully recoverable under their contract. Similarly, due to the very close working relationship, which occurs between engineers and detailers, efficiencies in the steel design and documentation process would occur if detailers were a separate or sub-consultant to the engineers.

Although only briefly mentioned in the results of the workshops, an issue that is considered worth noting for additional research is that of the competency levels of designers generally.

Both contractors and designers indicated the increasing use of junior and inexperienced staff to carry out the design function. Designers suggested that this was a direct result of reduced fees and inadequate design time, limiting the type of staff available and the extent of supervision and in-house training provided. Concern is raised that if, due to modern design firm pressures, adequate supervision and in-house training from senior staff is not supplied, the knowledge base of future designers may be diminished.

It is hoped that the results of the industry survey (Section 8) will finally determine whether an overall reduction in project design fees in the Australian construction industry over the past 10–15 years, has directly contributed to the claimed increase in design and documentation deficiency and the corresponding decline in construction process efficiency.

Should the results of the survey indicate that a causal relationship between low design fees, design deficiency and increased project costs does exist, it is hoped that the evidence provided will be sufficient to convince clients and developers to look beyond initial cost, when procuring design and documentation services.

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Australian Institute of Steel Construction (AISC)

Electrical Contractors Association - Major Contractors Group (ECA)

National Electrical Contractors Association (NECA)

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**Table 1. Responses from contractors' workshop rated as significant
(1 = least significant and 7 = most significant).**

Responses to question	Group no./item ranking					
	G1	G2	G3	G4	G5	Total
Insufficient coordination between design disciplines	7	7	7	7	7	35
Impractical details and construction methods (lack of constructability)	5	3			4	12
Inadequate design			5		5	10
Dimensional errors	6			3		9
Insufficient details (typical details insufficient for non-typical situations)			6	2		8
Use of unamended standard specifications from other projects		4		4		8
Late production of colour and finishes schedules	4				2	6
Lack of knowledge (by designers) of local by-laws or BCA requirements				5	1	6
Natspec clauses used without being modified to be project specific		6				6
Ambiguity in documents					6	6
Lack of programming for issue of design and documentation and critical decisions (process)				6		6
Site constraints not being checked		5				5
Lack of Bills of Quantities			4			4
Mixing of prescriptive and performance specification clauses within the same document	2		1			3
Incorrect use of materials/products specified (contrary to manufacturers' specifications)	3					3
Insufficient space allowed for the installation of complex services required within a building					3	3
Reliance on contractor to interpret requirements from design documents			3			3
Reliance of specification notes, in areas where drawings are required		2				2
Design not achievable within the project budget			2			2
Inaccurate or non-standard or poorly prepared Bills of Quantities				1		1
Incompatible products being specified – but with builder being responsible for consequences		1				1
Use of 'catch all' clauses (requiring the builder to allow for and be responsible for items not designed, detailed or specified)	1					1

**Table 2. Responses from designers' workshop rated as significant
(1 = least significant and 7 = most significant).**

Responses to question	Group no./item ranking										Total
	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9	G 10	
Low fee structures	6	7	6	7	6	5	7		7	7	58
Insufficient overall design time (to ensure incorporation of user requirements)	7	4	7		7	6	5		6	6	48
Inadequate or moving client brief		6	2			4	6	5	5	4	32
Unrealistic expectations by clients – in relation to fees, service, timing, etc.			5			7		7		5	24
Inadequate or insufficient estimates/budgets	3	5		1			4			2	15
Unpaid design submissions				6	3	1			4		14
Insufficient profits generated for training staff			3			3		4	3		13
Uncertainty of design brief at bid stage				3				6		3	12
Finding good staff (e.g. specification writers and construction detailers)	5					2	3				10
High cost of Design and Construct (D & C) submissions			1	5				2			8
Design changes requested, without being prepared to pay for them					5				2		7
Builder-initiated changes (D & C)	1			2					1		4
Fellow consultants having reduced service – incompatible with overall team requirements							1	3			4
Convincing clients of the value of comprehensive and clear documentation			4								4
No one person or office is responsible for coordination	4										4
Builder-employed design managers				4							4
Proliferation of 'backyard' operators					4						4
Lack of understanding by client of the value of Bills of Quantities		3									3
Interfacing between multiple contracts							2				2
Architect does not state exactly what is required					2						2
Improper implementation of CAD	2										2
Being engaged on a 'design only' basis					1						1
Cost of 'expressions of interest' (EOI)										1	1
Quality assurance (QA)								1			1

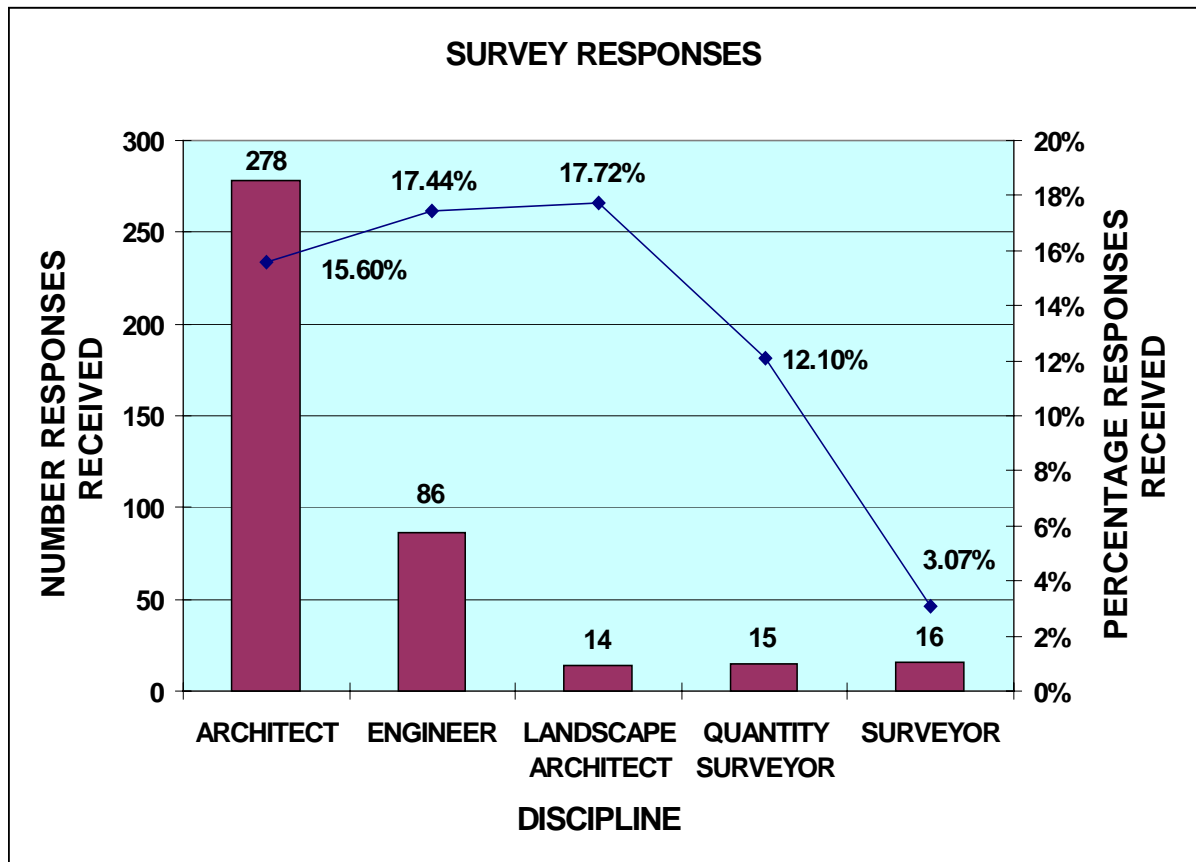


Figure 1: Breakdown of 'Designer's Questionnaire' responses by discipline