Design and Documentation Quality Survey

Contractors' Perspective

A Survey Investigating Changes in Design and Documentation Quality within the Australian Construction Industry and its Effect on Construction Process Efficiency

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Executive Summary

Background

The CSIRO Division of Building, Construction and Engineering – in collaboration with the Australian Construction Industry – recently undertook an investigation into the issues affecting design and documentation quality and their impact on the efficiency of the construction process. To carry out this task, a national survey, targeting designers, main contractors and trade contractors, was undertaken. Through this survey, the main factors affecting design and documentation quality, as well as the most significant impacts on the efficiency of the construction process in Australia, have been identified.

To carry out the study, the industry was partitioned into two sectors – designers and contractors – with each being surveyed separately using different survey forms. To ensure that the survey addressed only pertinent issues, industry workshops 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, provided valuable industry information that was used in the development of the survey questionnaires. The various industry organisations representing both designers and contractors were also actively involved in the development and distribution of the survey documents.

The overall aims of the study were to:

- identify those issues which affect design and documentation quality;
- determine whether there has been any changes over the past 15 years in the levels of design and documentation quality;
- determine what impact changing design and documentation quality standards may have on construction process efficiency; and
- assess the impact of these changes on project cost and time.

It should be noted however that whilst outlining the aims and objectives of the overall study, this report has been prepared specifically in relation to the results achieved from the contractors' survey only. The results of the designers' survey and a comparative analysis of the two sets of results are the subject of separate reports.

Survey Questionnaire

The contractor's questionnaire was developed from the results of industry workshops and consisted of four sections designed to obtain the following information:

- the changes in the level of the design and documentation quality;
- areas of design and documentation deficiency;
- the nature and extent of the impact of design and documentation deficiency on construction process efficiency; and
- organisational profiles and general comments.

In addition to these issues, the survey also enabled contractors to compare design and documentation quality between the public and private sectors as well as determine the impact that different procurement methodologies have on the quality of design and documentation provided.

Survey

The contractor's questionnaire was distributed to 2436 individuals and firms, representing various head contractor and trade contractor organisations. The trade contractor organisations involved, included mechanical contractors, electrical contractors, plumbing contractors, steel fabricators and steel detailers. The responses to the contractor's questionnaire from all respondents surveyed totalled 327 – which represents a total response rate of 13.4%. With all states and industry associations being represented, this number of responses ensures that the survey results are generally representative of the contractors' sector of the industry.

Results

Overall

The respondents were classified by a number of factors based on information obtained from the organisational profile section of the survey. Based on the analysis carried out, it was determined that of the factors identified, only the organisation association factor was consistently of statistical significance. For the various issues raised in the survey, the head contractors were generally in close agreement with each other as were the trade contractors, although the trade contractor's responses tendered to vary in their level of agreement. Overall the magnitude of the differences in the mean responses for specific issues between the head contractors and trade contractors was only small and as such, the results of the analysis provided in the report are reflective of the respondents collectively. The minimal variation in the responses overall indicated the population was homogeneous and as such any results can be considered as reflective of the entire population.

Changes in Levels of Design and Documentation Quality

As the overall quality of design and documentation is to a large extent determined by the level of incorporation of a number of attributes of design and documentation quality, any improvement or decline in their level of incorporation is likely to be reflected in the overall quality of design and documentation being produced. By asking contractors to indicate whether there have been any significant changes in the level of incorporation of those attributes over the past 15 years, it is possible to obtain an indication of changes in overall design and documentation quality. To verify the overall results obtained from the analysis of the responses relating to the design and documentation quality attributes, contractors were also asked specifically whether they considered there had been a decline in both design and documentation quality.

When considering the design quality attributes, the overall average combined response initially indicated a slight increase in their level of incorporation, over the past 15 years. Based on the above, this would appear to indicate a slight improvement in overall design quality. The design quality attributes that actually showed the greatest improvement were:

- consideration of *ecological sustainability* issues; and
- *material efficiency* – ensuring the efficient use of materials.

The attributes that showed the greatest decline however, were:

- *proper examination of design proposals* – to prevent ambiguity, omissions and errors; and
- *constructability* – incorporating constructability principles.

However, when contractors were specifically asked if they believed the overall quality of design had declined over the past 15 years, almost 70% agreed. Although this apparent discrepancy is explained mathematically, it is also considered that those attributes that were

shown to have declined, may have a greater impact on the perception of overall design quality, than those attributes which showed an improvement.

When considering the documentation quality attributes, the overall average combined response indicated a significant decline in their level of incorporation over the past 15 years. Again based on the above, this would appear to indicate a significant decline in overall design quality. The only attribute showing an improvement, was:

- *standardisation* – use of standard details and specifications.

The attributes that showed the greatest decline however, were:

- *accuracy* – drawings and other documents are free of errors, conflicts and inconsistencies; and
- *completeness* – drawings and other documents provide all the information required.

When contractors were specifically asked if they believed the overall quality of documentation had declined over the past 15 years, 88% agreed thereby confirming the results relating to the documentation quality attributes. When asked to compare the decline in both design and documentation quality, the majority of contractors (82%), believed that the decline in documentation quality has been the more significant.

Contractors were also asked to compare the quality standards of design and documentation coming from both public and private sector clients and although a higher percentage indicated the quality of private sector design and documentation was as good, if not better than the public sector, the results were fairly inconclusive.

Areas of Design and Documentation Deficiency

Using the results from the industry workshops, a number of issues were identified as being detrimental to design and documentation quality. By determining the frequency with which these issues occur and also the effect they have construction process efficiency, when they occurred, the major problem areas can be identified. Contractors were also asked to rate the quality of design and documentation that was produced under three different procurement methods – *traditional*, *design and construct* and *management* – to see if the procurement methodology had an impact on design and documentation quality.

Overall, contractors consider that documentation deficiency issues occur more frequent than design deficiency issues, however the effects of both were similar and highly detrimental to construction process efficiency. Documentation issues providing the greatest concern to contractors included:

- documents lacking *clarity* – forcing contractors to interpret requirements; and
- documents issued with *conflicting, incorrect* or *inaccurate information.*

The design issues providing the greatest concern to contractors included:

- *Inadequate* or *insufficient design work being carried out*; and
- *insufficient design coordination* – causing clashes between building and services elements.

When comparing the different quality levels achieved under the different procurement methods, it was found that both design and documentation quality had declined under each procurement method, but that the level of decline had been greatest under the *traditional* procurement method. The current rating for documentation quality was below the rating for design quality for each procurement method indicating the decline in documentation quality had been the more severe. Based on the results, contractors believe that both design and

documentation currently being produced under both *design and construct* and *management* methods, are of a marginally higher standard than that produced under the *traditional* method.

Nature and Extent of the Impact of Design and Documentation Deficiency on Construction Process Efficiency (CPE)

Having looked at the extent to which deficiencies in design and documentation occur and how they impact on both the efficiency of the construction process and overall perceptions of design and documentation quality, it is then important to determine what direct impact they have on overall project time and cost. This is achieved by firstly considering the impact that different levels of design and documentation quality have on project time and cost estimates – at tender stage – and then looking at a number of non-desirable elements of construction – that have a direct impact on final project time and cost – to determine:

- what proportion are as a direct result of design and documentation deficiencies;
- to what extent have their occurrences changed over the past 15 years; and
- to what extent has the administrative time and cost required to deal with them, changed over the past 15 years.

The price of design and documentation deficiency to the clients and developers is ultimately higher project costs and longer project duration, as most contractors add an additional percentage margin to both the tender price submitted and the time allowed to complete the project, to compensate for poor quality design and documentation. The extent of this additional allowance is generally determined by the perceived standard of design and documentation provided – the worse the quality standard, the greater the additional allowance. Based on the current average standard of design and documentation being rated between "*average*" and "*poor*", the respondents have indicated that an average additional allowance of between 2.5% and 7.2% is being added to both the submitted tender price and the time to complete for new projects.

When the respondents were asked to consider what proportion of the non-desirable elements of construction listed, was directly attributable to design and documentation deficiencies, the results showed a consistently high proportion across all elements, with *requests for information* (RFIs) and *variations* being particularly of note. When asked to consider the changes in the extent of occurrence of these non-desirable elements over the past 15 years, the contractors indicated increasing quantities of RFI's, variations, rework, cost over-runs, extensions of time and contractual disputes in line with declining design and documentation quality standards. Overall, the average increase in the occurrence of these non-desirable elements was around 50% over that time period and as a consequence, contributes heavily towards decreased project quality and increased overall project time and cost.

This increased occurrence of non-desirable elements of construction has meant the managerial and administrative workload required to effectively these elements has also increased over the same time period. When asked to consider both the managerial and/or administrative time and cost expended on each problem area, the contractor's responses indicated an increase of more than 100% in both time and cost to look after these issues over the past 15 years.

Organisational Profile and General Comments

The aim of this section was to try to identify any trends within the industry by investigating the organisational profile of the various companies to which the respondents belong, as well as giving the respondents the opportunity to provide general comments relating to the issues raised in the questionnaire as well as the industry in general. Based on the responses provided, the characteristics of the contracting firms responding to the survey are as follows:

- almost 60% of respondent organisations have been in business in their state for over 15 years, with just 7% having only been in operation for 5 years or less;
- nearly 90% of respondents have worked in the construction industry for 15 years or more – ensuring the validity of the data obtained;
- medium to large size companies figure prominently, with 38.1% having between in 16 and 50 employees and a further 31.1% having more than 50 employees;
- 89.0% of respondent companies carry out work under the *traditional* method, 76.5% in *design and construct* and only 58.7% have projects using one of the *management* project delivery methods;
- the proportion of total turnover attributed to the *traditional* method (44.5%) is significantly greater than that produced under either the *design and construct* (30.5%) or the *management* (25.0%) project delivery methods;
- *government*, *heavy industrial* and *commercial* sectors, represent by far the most predominant areas of work, while the *residential* and *recreational* sectors were the least common work areas; and
- approximately 63% of contractors either have a fully implemented QA system or are in the process of attaining ISO 9000 accreditation. A further 29.7% utilise an "In House" QA system

In relation to general comments, 153 of the 327 respondents (46.8%), took the extra time to provide comments. While some of these respondents only provided a few comments, a large number offered several observations including what they felt was wrong with the industry and how we might go about improving the situation.

Through their comments, contractors have indicated that insufficient design fees, a decline in designer professionalism and professional standards and insufficient design time are the main factors influencing the current poor standard of design and documentation quality. Contractors also indicated that there are other industry and social costs that can be attributed to the poor standard of design and documentation, including such things as more frequent litigation and increased worker stress levels, not to mention the consequential flow on costs to the rest of the economy.

Conclusions and Recommendations

The results of the survey show an obvious need for an improvement in the standard of design and documentation produced for construction projects. Based on the responses, the benefits that could be achieved from a better standard of design and documentation would include;

- more projects being completed on time, within budget and with a reduced likelihood of legal action due to contractual disputes;
- less RFIs, variations and rework;
- contractors being able to minimise the management time and cost spent on non-value adding activities.

These benefits would ultimately be reflected in reduced project and contractual risk, reduced project time and cost and a higher level of profitability for clients, their consultants and the contractors.

By selecting design consultants based on low fee levels and minimum service and by reducing project time frames all in an effort to minimise costs, clients and developers were by their own actions, contributing to the problems that lead to inefficiencies in the construction process and increases in overall project costs and durations. The results of this survey clearly shows a need for clients and developers to allocate adequate funds and time to the planning

and design phases of a project, in order to maximise construction process efficiency and minimise overall project costs.

Improvements in construction process efficiency will result from creating an awareness of the value of quality design and documentation and the introduction of selection criteria that includes consideration of the designer's skills and experience.

1 Introduction

1.1 Background

For some time, industry analysts have portrayed the Australian construction industry as being uncompetitive and inefficient when compared to overseas, with the quality of design and documentation produced being of major concern to many parties within the industry (Syam, 1995). As the quality of the design and documentation produced has a major influence on the overall performance and efficiency of construction projects (Burati *et al*, 1992; Kirby *et al*, 1988)], it is vitally important that issues affecting design and documentation quality be identified and addressed.

Designers provide the graphic and written representations which allow contractors and subcontractors to transform concepts and ideas into physical reality. However, it is the quality of the design and documentation provided which determines how effectively and efficiently this transformation occurs. Inadequate and deficient design and documentation impacts directly on the efficiency of the construction process by leading to delays, rework and variations, which in turn, contribute to increases in project time and cost (Tilley and Barton, 1997).

In an ideal world, the design and documentation provided for construction projects would be complete, precise and unambiguous. Unfortunately, contractors are often supplied with project documentation that is considered to be substandard or deficient due to incomplete, conflicting or erroneous information. Design and documentation quality is greatly determined by the level of professional services provided, with the quality of these services generally being determined by how the services are selected and how the fees are negotiated (DeFraites, 1989). Where designers are selected on the basis of low design fees, then the level and quality of the service provided is likely to be limited and generally translates into additional project costs to the owner.

A recent study of the relationship between fee structure and design deficiency showed that design deficiency had a non-linear inverse relationship with project design fees (Abolnour, 1994) and that project costs due to design deficiency increase sharply when design fees are reduced below their optimal level (Abolnour, 1994; McGeorge, 1988). The concept of reducing total project costs by increasing expenditure on the design process has also been well documented through the principles of value engineering (Green, 1990) and value management (Barton, 1996). It would appear therefore, that the truism, *'you get what you pay for'*, is very appropriate when it comes to procuring design services.

But what is design and documentation quality and how is it measured? One definition relating to design quality (McGeorge, 1988) states:

> *"a good design will be effective (ie, serve the purpose for which it was intended) and constructible with the best possible economy and safety."*

However, while the design itself needs to be "effective", it also needs to be communicated effectively through the documentation (*i.e.*, drawings, specifications, Bills of Quantities). When documentation quality is considered, a number of attributes – such as timeliness, accuracy, completeness, coordination and conformance – are looked at to determine the level of quality achieved (Tilley *et al*, 1997). Therefore, by measuring the extent to which attributes of design and documentation quality are incorporated, we can determine the quality of design and documentation achieved (Tilley *et al*, 1997).

With this in mind, CSIRO Building, Construction and Engineering investigated design and documentation quality within the Australian construction industry, with the overall aim of the study being to:

- identify those issues which affect design and documentation quality;
- determine whether there has been any changes over the past 15 years in the levels of design and documentation quality;
- determine what impact changing design and documentation quality standards may have on construction process efficiency; and
- assess the impact of these changes on project cost and time.

To carry out this investigation, it was decided to conduct a national survey of both the design professions and the various head and trade contracting organisations. To ensure that the survey addressed only pertinent issues, industry workshops 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, provided valuable industry information that was used in the development of the survey questionnaires.

The purpose of this report is to not only provide project sponsors with the results of the contractor's questionnaire conducted by the CSIRO, but also inform the industry as a whole as to the causes and effects of design and documentation deficiency from the contractors' perspective.

1.2 Contractor's Survey Questionnaire

To study this problem a number of alternatives were considered, however a postal survey was ultimately selected as it was decided that this method would most likely provide the quantity of reliable information required to allow a valid statistical analysis within the budgetary confines of the project. During the development of the questionnaire, special consideration was given to question length and clarity to try to minimise the chance of misinterpretation of the questions and maximise the reliability of the responses. To ensure that the survey only addressed pertinent issues, all the various industry sponsor organisations – through a Project Steering Committee – were actively involved in the development of the survey documents, by providing:

- advice on what information was likely to be available from the industry,
- comments on the development of survey questions and format, and
- information on specific issues that should be included in the questionnaire.

The contracting groups to which the questionnaires were sent along with their representative industry association, are shown in Table 1.1:

Table 1.1 Contracting groups and representative industry associations

Contracting group	Representative industry associations
• Head Contractors	• AIB – Australian Institute of Building & • MBA – Master Builders Associations (all states and territories)
• Air-Conditioning/Mechanical Contractors	• AMCA – Air conditioning and Mechanical Contractors Association
• Electrical Contractors	• ECA – Electrical Contractors Associations (National and Queensland)
• Plumbing Contractors	• MPA – Master Plumbers Association
• Steel Fabricators & • Steel Detailers	• AISC – Australian Institute of Steel Construction

The contractor's questionnaire was set out into four sections to obtain from the various contracting groups, the following information:

- whether over the past 15 years, there has been any changes in the levels of design and documentation quality and if so, determining the extent of that change;
- what are the major areas of design and documentation deficiency, how frequently do they occur and what impact do they have on the efficiency of the construction process;
- whether different procurement methodologies have had an impact on the level of design and documentation quality achieved;
- whether there were any differences in the quality design and documentation produced for either public and private sector clients;
- what impact design and documentation quality has on cost and time estimates for tendering purposes;
- what proportion of the undesirable elements of construction can be attributed to design and documentation deficiencies;
- whether over the past 15 years, there has been any changes in the extent of a list of undesirable elements of construction;
- whether over the past 15 years, there has been any changes in the managerial or administrative cost and time allowed to look after these undesirable elements of construction;
- an overall profile of contracting firms within Australia, for comparative purposes.

It is hoped that the information obtained will help to determine not only the major issues directly affecting the quality of design and documentation currently being produced, but also to devise strategies to eliminate the problems or at least minimise their impact.

1.3 Response Demographics

The survey questionnaire was distributed to 2436 head and trade contracting organisations nationally. The overall number of responses to the contractor's questionnaire from all disciplines surveyed totalled 327 – which represents a total response rate of 13.4%. with most contracting groups being well represented (see Figure 1.1).

As can be seen, the only construction group not to achieve a strong response rate was the plumbing group, which was only able to provide a less than 3% response rate. Unfortunately, there are no explanations as to why the response rate from the plumbing group should be so

low. One would have expected that plumbers would have had the same interest in the issues raised as any of the other contracting groups surveyed.

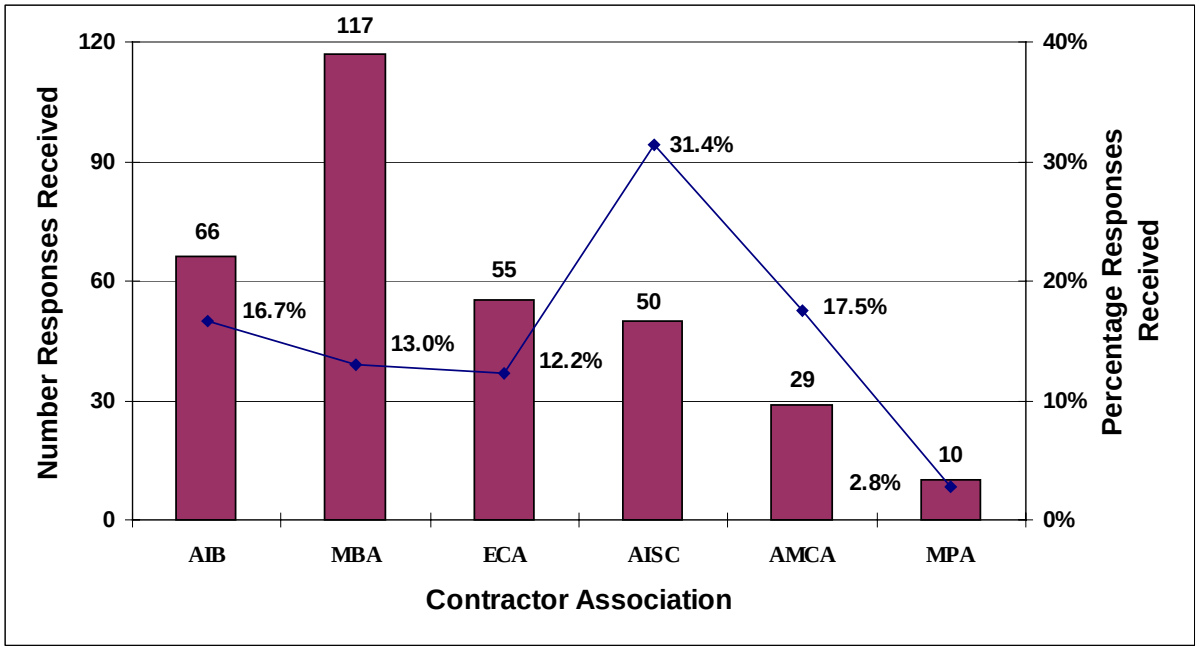


Figure 1.1 Survey responses – by construction group associations

As with the construction groups, most states and territories were also well represented (see Figure 1.2) thereby reinforcing the fact that this was a national survey.

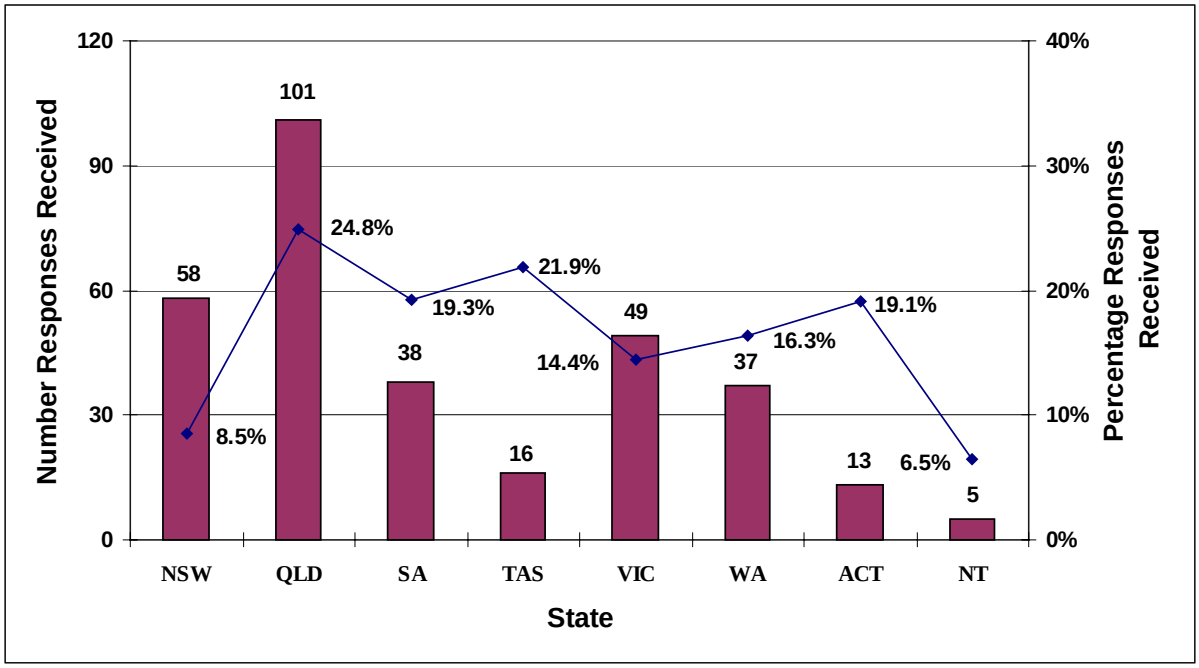


Figure 1.2 Survey responses – by state/territory

As can be seen from the chart, apart from the Northern Territory and New South Wales, the response rates were reasonably good for this type of survey, with Queensland and Tasmania in particular providing very good results.

Although the total number of responses received were less than hoped for, the overall quantity and range of responses are statistically significant and ensure that the results of the analysis

can be considered to be generally representative of the construction sector of the industry, as a whole.

1.4 Response Analysis

To determine if there were any differences in the responses in any of the contractor categories within the Australian construction industry, respondents were coded for a number of different factors, as shown in Table 1.2:

Table 1.2 Response analysis factors

Response analysis factors	Factor description
• *Years*	• Years of operation in their state
• *Size*	• Size of organisation – based on number of employees
• *QA*	• Level of quality assurance attained
• *State*	• The state in which the contractor works
• *E-mail*	• The e-mail capacity of the contractor
• *Field*	• The contractor's industry association

These six factors, when combined, provided 15 two-way interactions and if any of the interactions proved notable, then higher order interactions would be considered.

Based on the analysis carried out, it was determined that of the six factors identified, only industry association (*Field*) factor provided any differentiation that was consistently of statistical significance. For the various issues raised in the survey, the MBA and the AIB (which generally represented the *head contractor* group) were generally in agreement while the other association's members' responses (which generally represented the *trade contractor* group), tendered to be more varied in their level of agreement. As an example, the AISC members' responses were often similar to those from the MBA and AIB while the members of the AMCA consistently had more variation in their responses. The only organisation that did not provide a good response rate was the MPA where only 10 members responded. Given the response rate, the analysis results were checked at all times for any effect due to the MPA, however the responses from the MPA were generally consistent with those from the other industry associations and as such had little impact.

The mean response from the various fields for the survey differed in magnitude for some issues; these differences however were generally small and do not impact on the outcome of the survey as a whole. Therefore although the *Field* factor was statistically significant, due to the relative size of the differences the overall mean response is generally considered representative and so is therefore used through out this report. Where the magnitude of the difference is notable, the differences have been included in the report as a characteristic for the issue. Other factors and combinations of factors were, at times, of statistical significance but in practice the differences were very small and their existence does not alter the findings of this analysis. However, again for completeness, their existences have been noted where they occur.

2 Survey Results

The responses were entered into a simple relational database and a statistical analysis of the data was undertaken to enable a full understanding of the contractors' perspective. The results from this analysis are detailed below.

2.1 Section 1 – Changes in Levels of Design and Documentation Quality

2.1.1 Section 1 – Overview

Section 1 deals with the changes in the level of design and documentation quality over the past fifteen years. To accomplish this, the section examines a number of attributes of design and documentation quality and investigates whether there have been any significant changes in the level of incorporation of those attributes over the past 15 years. As the overall quality of design and documentation is to a large extent determined by the level of incorporation of such attributes, any improvement or decline in their level of incorporation is likely to be a reflection of the overall quality of the design and documentation being produced. As part of the investigation, contractors were also asked specifically whether they considered there had been a decline in both design and documentation quality. The responses to these specific questions could then be used to verify the overall results obtained from the analysis of the responses relating to the design and documentation quality attributes.

When considering the *design* quality attributes, a simple analysis of the responses indicated a slight increase in the overall average level of incorporation of the design quality attributes as a whole, over the past 15 years. Looking at the design quality attributes individually, the attributes showing the greatest improvement, included *ecological sustainability* and *material efficiency*. The issues showing the greatest decline however, included the *proper examination of design proposals* and *constructability*.

Although the results indicated a slight improvement in the overall average level of incorporation of the design quality attributes as a whole over the past 15 years, when contractors were specifically asked whether they felt that design quality had declined, 69% said "*Yes*". This discrepancy between the two results, would appear to indicate that not all of the design quality attributes are considered by the contractors, to be of equal weighting and that those attributes which were shown to have declined, may have a greater impact on the perception of overall design quality, than those attributes which showed an improvement.

When considering the *documentation* quality attributes, an analysis of the responses indicated that contractors believe the overall average level of incorporation for documentation quality attributes as a whole, had declined significantly over the past 15 years. Looking at the documentation quality attributes individually, the only attribute showing an improvement, was *standardisation*. However, the issues showing the greatest decline, included *accuracy* and *completeness*.

When these results were compared with the responses to the specific question which asked whether they felt that documentation quality had declined, 88% said "*Yes*", thereby confirming the results of the previous question. Due to these results, it was therefore not unexpected to find that when asked to compare the decline in both design and documentation quality, the majority of contractors (82%), believed that the decline in documentation quality has been the more significant.

Contractors were also asked to compare the quality of design and documentation coming from both public and private sector clients. The results indicated that while contractors were fairly evenly split on the topic a greater proportion did indicate that the overall quality of design and documentation was "*not*" greater in the public sector than in the private sector.

2.1.2 Question 1.1 – Changes in the Level of Incorporation of Design Quality Attributes

Question 1.1 looks at a number of attributes of design quality and investigates whether there have been any significant changes to those attributes over the past 15 years by asking the contractors to rate the level of incorporation of each attribute at three specific time periods. To measure the level of incorporation of each attribute, the rating scale ranged from 0 (*Not at all*) to 10 (*Completely*). The design quality attributes surveyed are listed in Table 2.1.

Table 2.1 Design Quality Attributes

Design Quality Attributes
a) Consideration of whole life–cycle issues
b) Material efficiency – ensuring the efficient use of materials
c) Economy – ensuring design solutions are cost effective
d) Relevancy – ensuring project requirements are met
e) Constructability – incorporating constructability principles
f) Innovation – incorporating innovation in the design solution
g) Expressiveness – provides symbolic expression and feeling
h) Aesthetics – the finished product is visually pleasing
i) Consideration of ecological sustainability issues
j) Site compatibility – effectively uses and makes due allowance for site conditions
k) Material selection – ensuring the availability, suitability and compatibility of materials
l) Proper examination of design proposals (to prevent ambiguity, omissions and errors)
m) Functionality – effectively serves the purpose for which it was intended

A simple analysis of all the design quality attributes, appears to indicate a slight overall improvement in their level of incorporation during the past 15 years – with eight of the thirteen attributes showing an improvement. However, it is also worth noting that for the majority of the design quality attributes, the change in their level of incorporation was only marginal. As can be seen in Figure 2.1, the design quality attributes that showed the greatest increase in their level of incorporation were:

- Consideration of ecological sustainability issues;
- Material efficiency – ensuring the efficient use of materials; and
- Innovation – incorporating innovation in the design solution.

In contrast, the design quality attributes to record the most significant decline, were:

- Proper examination of design proposals (to prevent ambiguity, omissions and errors);
- Constructability – incorporating constructability principles; and
- Material selection – ensuring the availability, suitability and compatibility of materials.

However, when considering the current time frame, the issues rated as having the lowest levels of incorporation included:

- Proper examination of design proposals (to prevent ambiguity, omissions and errors);
- Consideration of whole life–cycle issues; and
- Constructability – incorporating constructability principles.

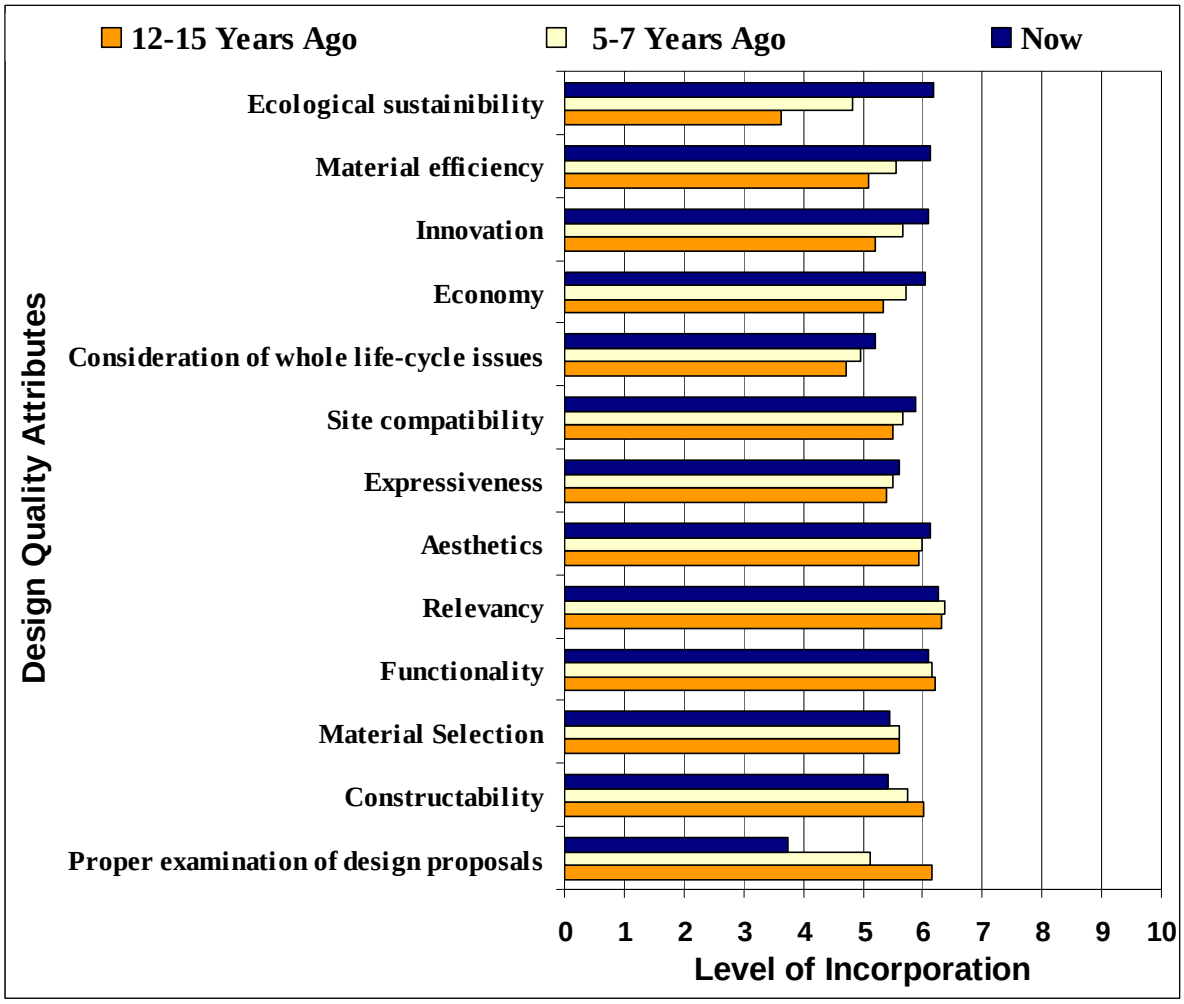


Figure 2.1 Changes in levels of incorporation of design quality attributes over the past 15 years

These results clearly highlight that one of the major concerns of the contracting sector within the construction industry, relates to the quality and suitability of design proposals, not only with respect to design practicality and ease of construction, but also in relation to long term maintenance and life-cycle issues.

When considering the six analysis factors (as listed in Table 1.2), the analysis showed that while all were statistically significant for this question – including the interactions between the factors – the degree of difference in the responses for each factor was generally only minor. The only factors that were of note were the *State* and *Field* factors. In relation to the *State* factor, the responses from the Australian Capital Territory contractors were consistently around 10% below the mean responses for all the other respondents at all time periods. This would appear to indicate that in their opinion, design quality attributes had not been incorporated to the same degree as was perceived by contractors from all the other states.

When considering the *Field* factor, *head contractors* – identified as being members of either the MBA or the AIB – generally were more positive in relation to those attributes that had improved and more conservative in relation to those attributes that had declined, than the *trade contractors* were.

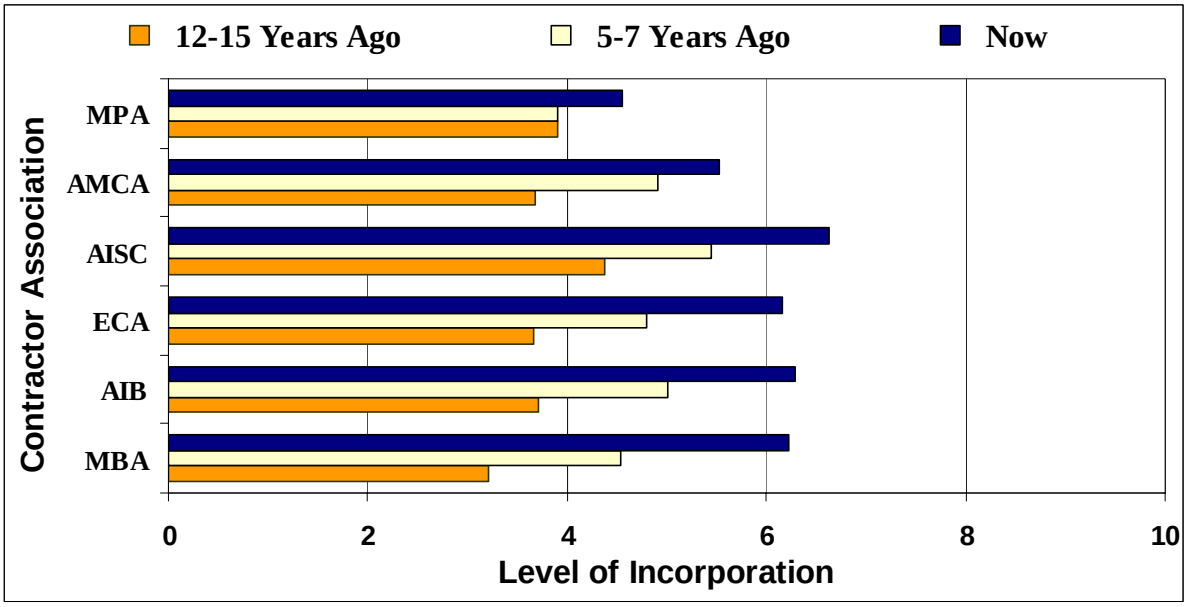


Figure 2.2 Breakdown of the *ecological sustainability* attribute by contractor association

As can be seen in Figure 2.2, while all contracting groups agree that the incorporation of *ecological sustainability issues* has improved over the past 15 years, the head contractors generally indicate a greater level of improvement than do the trade contractors.

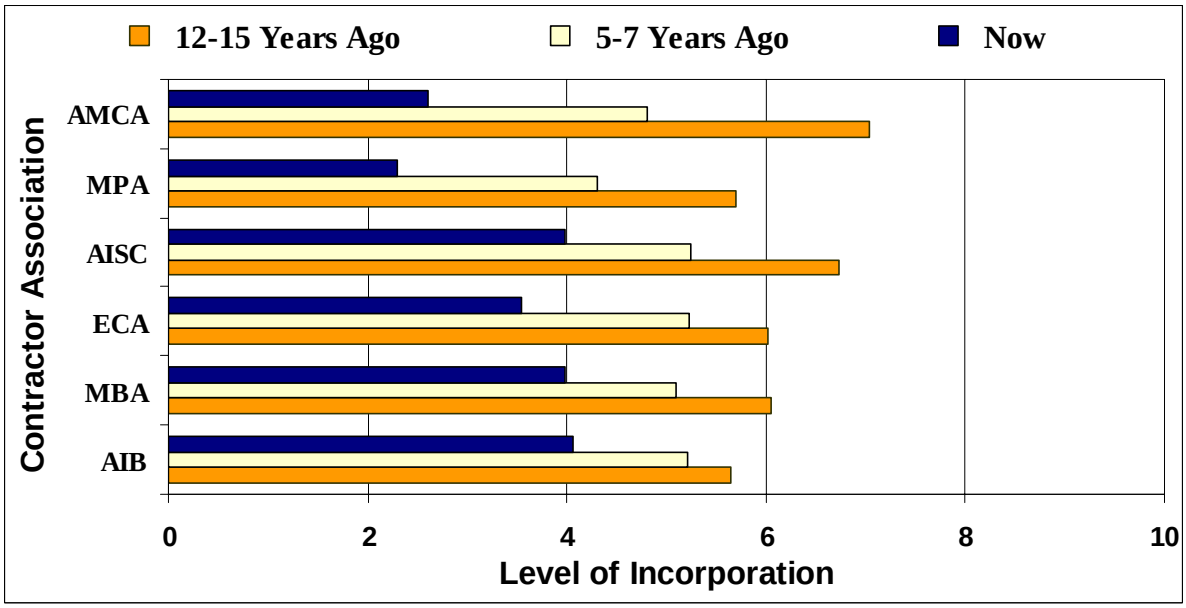


Figure 2.3 Breakdown of the *proper examination of design proposals* attribute by industry association

However, in Figure 2.3, while again there is general consensus between all contracting groups that there has been a decline in the *proper examination of design proposals*, the head contractors indicate a lesser decline than do the trade contractors.

2.1.3 Question 1.2 – Has there been a Decline in Overall Design Quality?

Having looked at the changes in the levels of incorporation of design quality attributes in Question 1.1, in Question 1.2, contractors were specifically asked to consider whether or not there had been a decline in design quality over the past 15 years, with the available responses being either:
a) *Yes*; b) *No*; or c) *Unsure*.

In Figure 2.4 below, we can see that just over two-thirds (69%) of the respondents agreed that the overall quality of design had declined over the past 15 years. While a little under a third (27%) of respondents disagreed, only 4% were unsure.

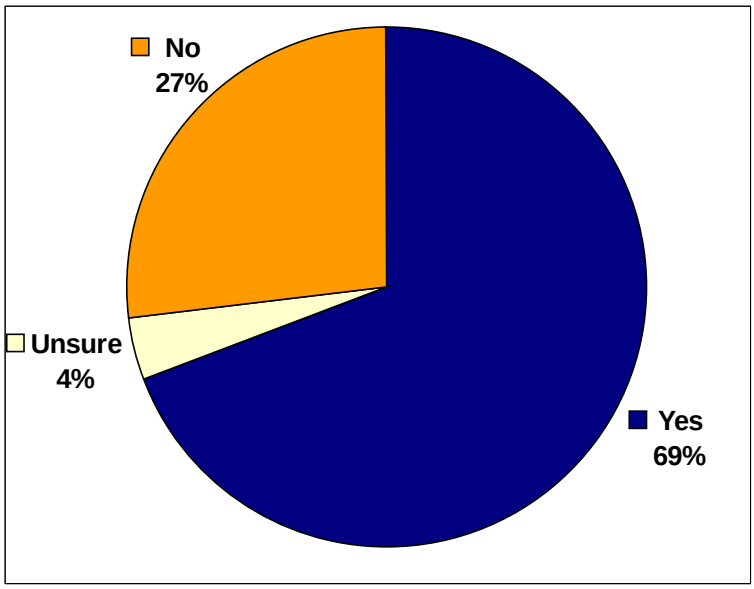


Figure 2.4 Response to whether there had been a decline in overall design quality over the past 15 years – total

When checking the results across contracting groups, it was found that there was a high level of agreement among the contractor associations, especially the members of the AMCA, that there had been a decline in the quality of design over the past 12 – 15 years (see Figure 2.5).

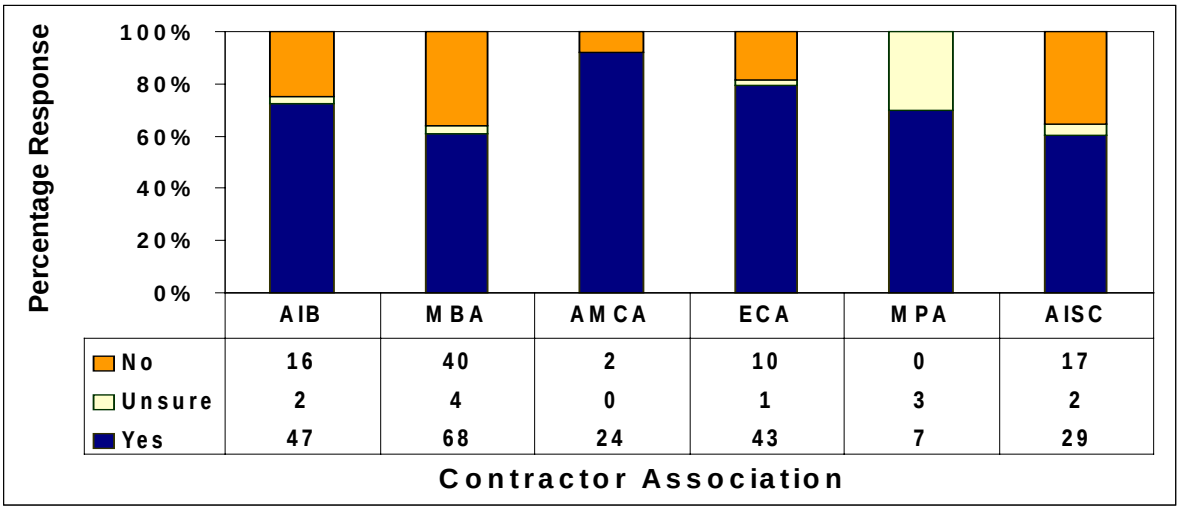


Figure 2.5 Response to whether there had been a decline in overall design quality over the past 15 years – by contractor association

However, as in Question 1.1, trade contractors were more definite, with nearly 75% indicating a decline compared to just 65% of head contractors. Given the results of Question 1.1, this response raises an important question. Why do contractors believe the quality of design has declined when an analysis of design quality attributes would appear to show an improvement? Although it is most likely that contractors consider the attributes that have shown a decline have a greater impact on their perception of design quality and therefore outweigh the attributes showing an improvement, this apparent discrepancy in the perceptions of the changes to design quality, required further analysis.

An analysis of the responses for the design quality attributes, which compared those respondents that answered "*Yes*" to Question 1.2 to those who answered "*No*", revealed that there was a statistically significant difference in the mean responses. Overall there were 218 respondents who believed that the quality of design had declined, 85 who believed the quality had not declined and 12 who were unsure.

The mean response for those who indicated that the quality of design had declined over the past 15 years was approximately 5.6 for the period 12 – 15 years ago, declining to approximately 5.2 for the current time period – with all issues pooled – suggesting that the decline was only slight. The mean response for those who indicated there had not been a decline in the quality of design was 6.8 for the current period up from 5.2 for the period 12 – 15 years ago, again with all issues pooled, thereby supporting their assertion that design quality had actually improved. Even for those who were "unsure", the mean response again showed an improvement from 5.0, up to 6.0 over the 15 year time frame.

Assessing the differences in the mean responses by issue, showed that those who indicated the quality of design had not declined had a slightly more positive response for all issues than those who indicated the quality of design had declined, even though they started from a slightly lower position. This therefore provides an explanation for the apparent discrepancy in the overall perceptions. Figure 2.6 below illustrates the differences.

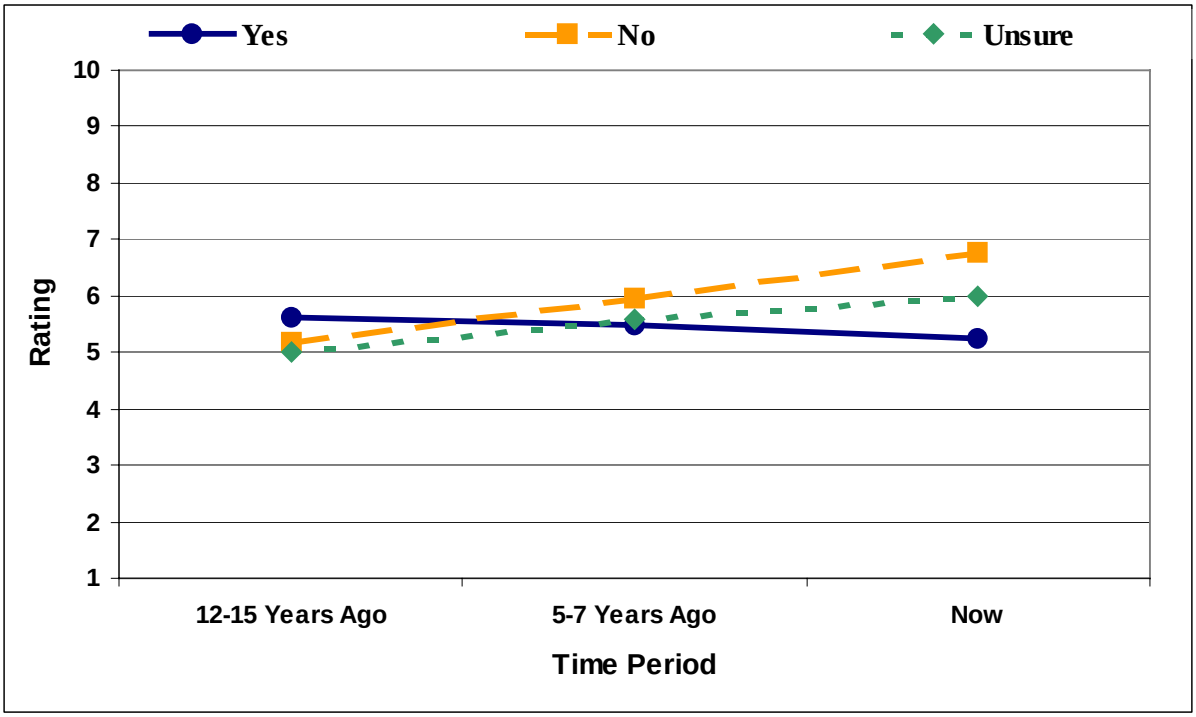


Figure 2.6 Mean overall response for design issues

2.1.4 Question 1.3 – Comparison of the overall quality of design over the past 15 years between *public* sector projects and *private* sector projects

Having looked at the changes in overall design quality, Question 1.3 asked contractors to compare both the *public* and *private* sectors, by asking them to indicate whether they felt design quality over the past 15 years had been greater on *public* sector projects than on *private* sector projects, with the available responses being either:
a) *Yes*; b) *No*; or c) *Unsure*.

In Figure 2.7 below, we can see that while just over a third (38%) of the respondents agreed that the quality of design was greater on public sector projects, a little under half (46%) disagreed with the statement, leaving the remaining 16% of respondents being unsure.

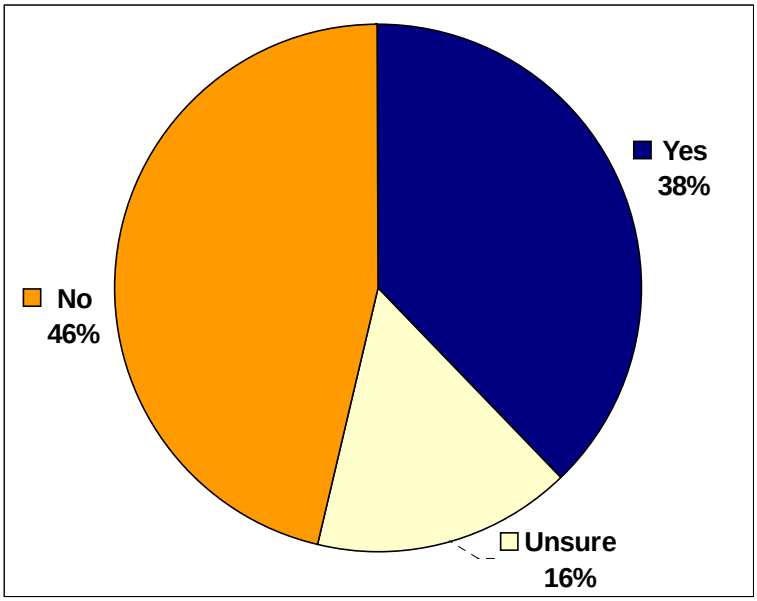


Figure 2.7 Response to whether the quality of design had been greater on public sector projects – total.

A breakdown of the responses by contractor association (see Figure 2.8) shows some differences in opinion between the various contracting groups, but none are considered significant.

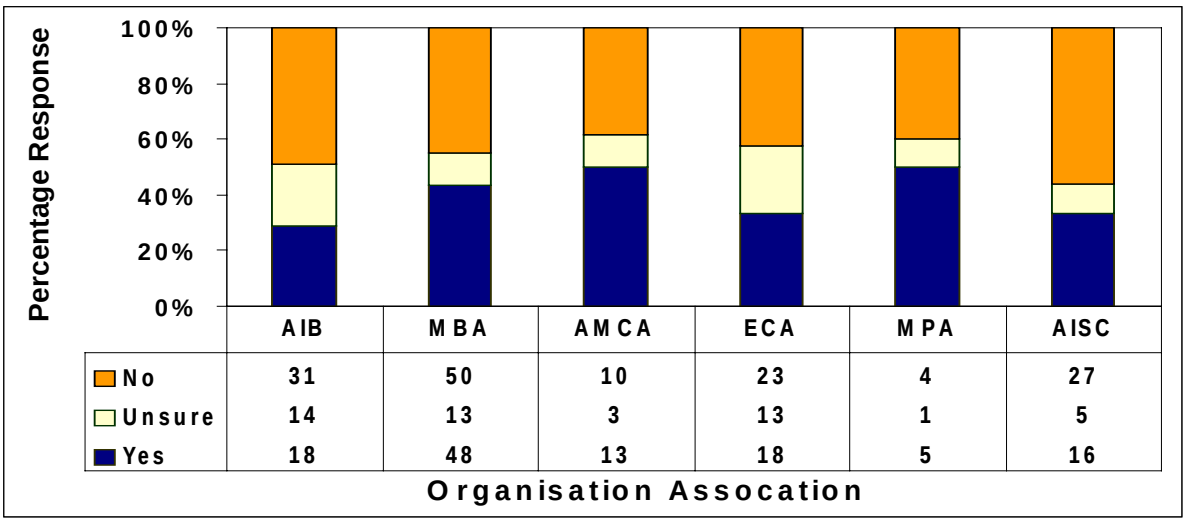


Figure 2.8 Response to whether the quality of design had been greater on public sector projects – by contractor association

2.1.5 Question 1.4 – Changes in the Level of Incorporation of Documentation Quality Attributes

Question 1.4 looks at a number of attributes of documentation quality and investigates whether there have been any significant changes to those attributes over the past 15 years by asking the contractors to rate the level of incorporation of each attribute at three specific time periods. To measure the level of incorporation of each attribute, the rating scale ranged from 0 (*Not at all*) to 10 (*Completely*). The documentation quality attributes surveyed are listed in Table 2.2.

Table 2.2 Documentation quality attributes

Documentation Quality Attributes
a) Completeness – drawings and other documents provide all the information required
b) Clarity – drawings and other documents are legible and are easily read and interpreted
c) Accuracy – drawings and other documents are free of errors, conflicts and inconsistencies
d) Final checking – drawings and other documents are properly checked prior to release to the contractor
e) Standardisation – use of standard details and specifications in drawings and other documentation
f) Relevance – trade specifications and details are specific, relevant and appropriate to the project
g) Timeliness – drawings and other documents are supplied when required, to avoid delays
h) Coordination – drawings and other documents are thoroughly coordinated between design disciplines
i) Certainty - drawings and other documents do not require changes or amendments
j) Conformity – drawings and other documents indicate the requirements of performance standards and statutory regulations

A simple analysis of all the documentation quality attributes, clearly showed a significant overall decline of nearly 37%, with nine of the ten attributes showing a marked decline in their level of incorporation during the past 15 years. As can be seen in Figure 2.9, the only documentation quality attribute to actualy show an increase in its level of incorporation was:

- Standardisation – use of standard details and specifications in drawings and other documentation.

In contrast, the documentation quality attributes to record the most significant decline, were:

- Accuracy – drawings and other documents are free of errors, conflicts and inconsistencies;
- Completeness – drawings and other documents provide all the information required; and
- Final checking – drawings and other documents are properly checked prior to release to the contractor.

However, when considering the current time frame, the issues rated as having the lowest levels of incorporation included:

- Certainty - drawings and other documents do not require changes or amendments;

- Coordination – drawings and other documents are thoroughly coordinated between design disciplines; and
- Accuracy – drawings and other documents are free of errors, conflicts and inconsistencies.

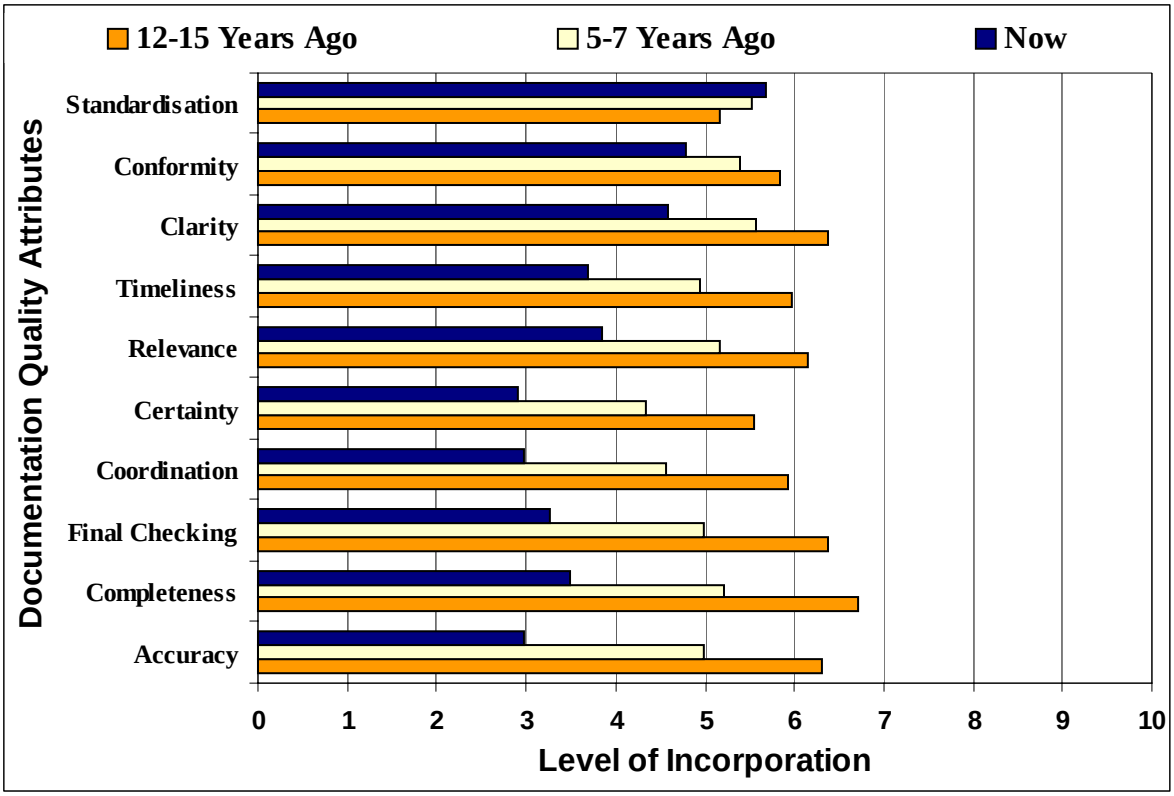


Figure 2.9 Changes in levels of incorporation of documentation quality attributes over the past 15 years

Again, as was the case for design issues, all factors (as listed in Table 1.2) were of statistical significance including the interactions between the factors. Generally, the degree of difference in the responses for the factors was only minor, except for the *State* and *Field* factors. In relation to the *State* factor, the responses from the Australian Capital Territory contractors were again consistently around 10% below the mean responses for all the other respondents at all time periods. Respondents from the Northern Territory however, agreed with those from the Australian Capital Territory for the earlier time periods, but not the current time period where the respondents from the Northern Territory were in line with the other states.

When considering the *Field* factor, although *head contractors* generally agreed with *trade contractors* that most of the documentation quality attributes had declined over the past 15 years, the extent of the decline was generally less than that shown by the *trade contractors*. The only issue on which the two groups disagreed, was in relation to the *standardisation* attribute. While the mean responses for *head contractors* showed an increase in the level of incorporation of *standardisation*, the mean responses for *trade contractors* showed a decline. In Figure 2.10 a breakdown of the *standardisation* attribute by industry association (*Field*), shows the difference in opinion between the two groups.

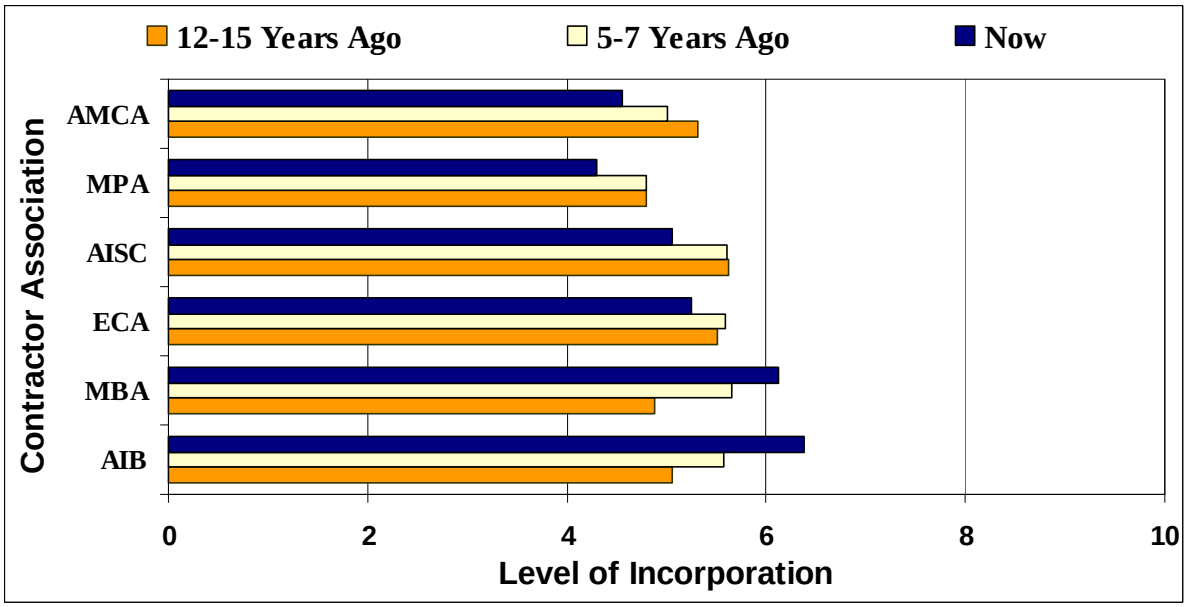


Figure 2.10 Breakdown of the *standardisation* attribute by contractor association

2.1.6 Question 1.5 – Has there been a decline in overall documentation quality?

Having looked at the changes in the levels of incorporation of documentation quality attributes in Question 1.4, in Question 1.5, contractors were specifically asked to consider whether or not there had been a decline in documentation quality over the past 15 years, with the available responses being either:
a) *Yes*; b) *No*; or c) *Unsure*.

In Figure 2.4 below, we can see that the vast majority (88%) of the respondents agreed that the overall quality of documentation had declined over the past 15 years. While just 10% of respondents disagreed, only 2% were unsure.

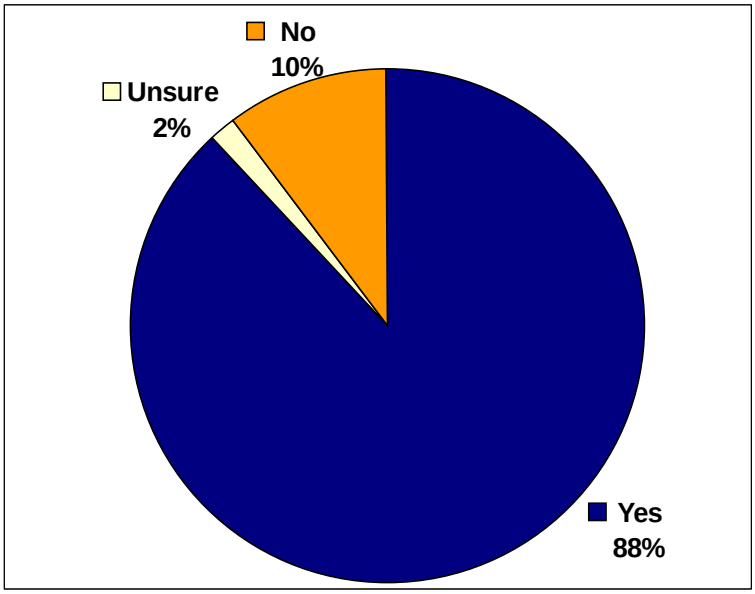


Figure 2.11 Response to whether there had been a decline in overall documentation quality over the past 15 years – total

This overwhelming response was fairly uniform across all the contracting groups (see Figure 2.5) and confirms the responses indicated in Question 1.4.

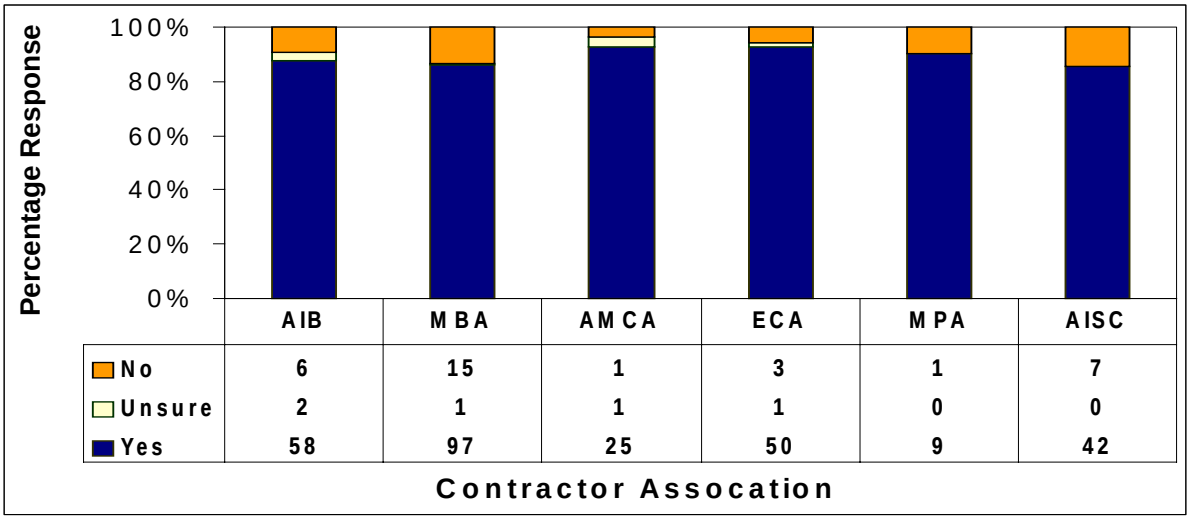


Figure 2.12 Response to whether there had been a decline in overall documentation quality over the past 15 years – by contractor association

2.1.7 Question 1.6 – Comparison of the level of decline in both design and documentation quality over the past 15 years

As it was expected that some of the contractors would indicate a decline in the quality of both design and documentation, Question 1.6 asked these respondents to consider both levels of decline and determine whether the decline in documentation quality had been greater than the decline in design quality, with the available responses being either:
a) *Yes*; b) *No*; or c) *Unsure*.

Although only 213 (65%) of all respondents indicated a decline in both design and documentation quality, 269 (82%) of all respondents answered this question. In Figure 2.13 below, we can see that a large majority (82%) of these respondents agreed that the decline in documentation quality had been greater than the decline in design quality. Of the remainder, 14% disagreed with the statement, leaving just 4% of these respondents being unsure.

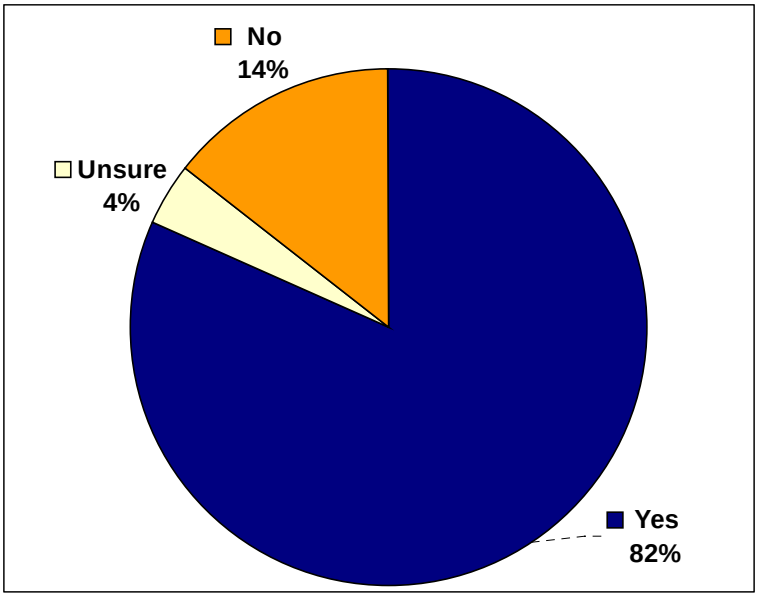


Figure 2.13 Response to whether the decline in documentation quality had been greater than the decline in design quality – total

A breakdown of the responses by contractor association (see Figure 2.14) shows some differences in opinion between the various contracting groups, but none are considered significant.

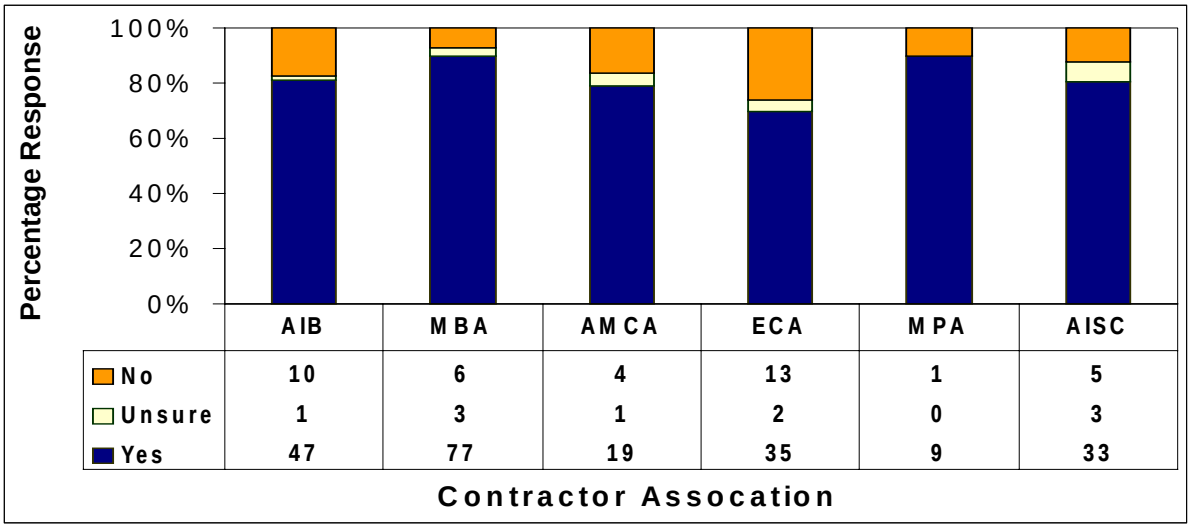


Figure 2.14 Response to whether the decline in documentation quality had been greater than the decline in design quality – by contractor association

2.1.8 Question 1.7 – Comparison of the overall quality of documentation over the past 15 years between *public* sector projects and *private* sector projects

Having looked at the changes in overall documentation quality, Question 1.7 asked contractors to compare both the *public* and *private* sectors, by asking them to indicate whether they felt documentation quality over the past 15 years had been greater on *public* sector projects than on *private* sector projects, with the available responses being either:
a) *Yes*; b) *No*; or c) *Unsure*.

In Figure 2.15 below, we can see that while just over a third (36%) of the respondents agreed that the quality of design was greater on public sector projects, a little bit more (41%) disagreed with the statement, leaving the remaining 23% of respondents being unsure.

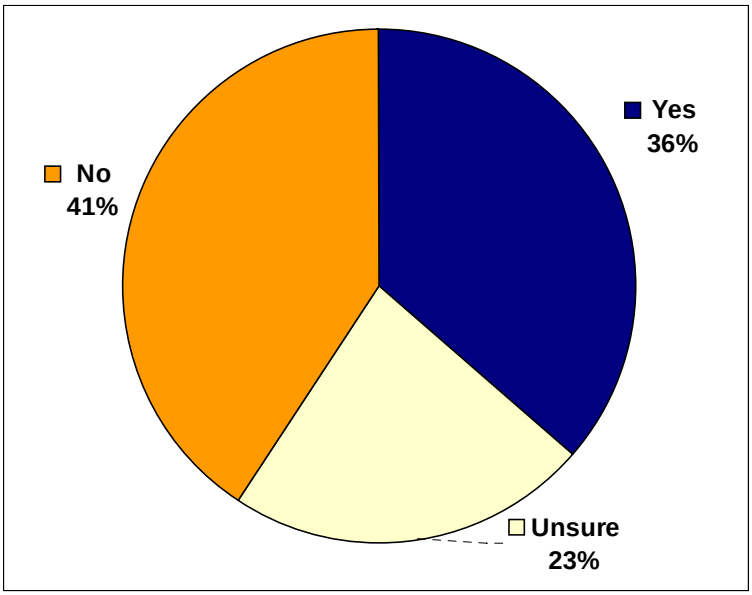


Figure 2.15 Response to whether the quality of documentation had been greater on public sector projects – total

A breakdown of the responses by contractor association (see Figure 2.16) shows some differences in opinion between the various contracting groups, but none are considered significant.

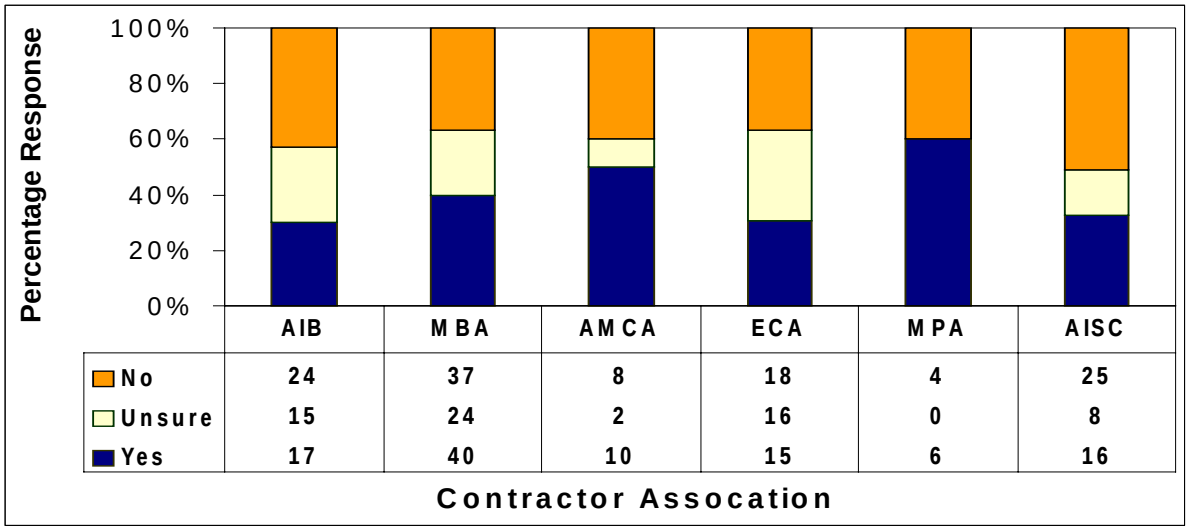


Figure 2.16 Response to whether the quality of documentation had been greater on public sector projects – by contractor association

These results are in line with the overall responses given in Question 1.3 in relation to design quality, with the responses by contractor associations also being directly comparable.

Comparing design issues and documentation issues over time, clearly indicates that those issues relating to documentation quality have been the major concern for contractors. This is evident from the responses to Questions 1.5 and 1.6 and highlights that the standard of documentation now is perceived to be well below the standard of design.

A correlation analysis of Questions 1.2 and 1.5 indicates that of the contractors who believe there has been a decline in the quality of design, almost all also believe that there has been a decline in the quality of documentation. However, there were also several respondents who indicated that the quality of design had not declined but that documentation quality had. Due to this, the correlation statistic is 0.44, which suggests a moderately positive relationship.

A similar analysis for Questions 1.3 and 1.7 showed that of those who indicated that the overall quality of design has been greater in *public* sector projects than in *private* sector projects, a reasonable percentage also agreed that the quality of documentation was also greater on *public* sector projects. The correlation statistic of 0.49, also indicates a moderately positive relationship between the two.

2.2 Section 2 – Areas of Design and Documentation Deficiency.

2.2.1 Section 2 – Overview

This section looks at a number of issues – identified at the contractor's workshop as being detrimental to design and documentation quality – and aims to determine not only the frequency with which they occur, but also the level of effect that they have on construction process efficiency, when they occur. Contractors were also asked to rate the quality of design and documentation that was produced under three different procurement methods – *Traditional*, *Design and Construct* and *Management* – to see if the procurement methodology had an impact on design and documentation quality.

When comparing the responses for frequency of occurrence and level of effect in relation to both design and documentation issues, the contractor's responses indicate that the documentation issues occur more frequent than the design issues but that the effect of both is similar and highly detrimental to construction process efficiency. *Inadequate* or *insufficient design work being carried out* and *insufficient design coordination* are the design issues that are most frequent and have the most effect on the construction process. The *design not being achievable within the project budget* is another design issue to impact negatively on the construction process. Documentation issues providing the most concern to contractors include documents lacking *clarity* or *having conflicting* or *incorrect information.*

When comparing the different quality levels achieved under the different procurement methods, it was found that both design and documentation quality had declined under each procurement method, but that the level of decline had been greatest under the *traditional* procurement method. The current rating for documentation quality was below the rating for design quality for each procurement method indicating the decline in documentation quality had been the more severe and confirms the perception that the decline in documentation has been greater than the decline in design – as indicated in Question 1.6. Based on the results, contractors believe that design and documentation currently being produced under both *design and construct* and *management* methods, is of a marginally higher standard than that produced under the *traditional* method.

2.2.2 Question 2.1 – Frequency of occurrence and level of effect of issues pertaining to design deficiency.

Question 2.1 looks at a number of design problem areas – previously identified at the contractor's workshop – and looks at determining not only how frequently they occur, but also what level of effect they have on construction process efficiency, when they occur. To measure the frequency of occurrence of each problem area, a five point rating scale – ranging from *Not at all* to *Always*, was used. However, to measure the level of effect, a nine point rating scale – ranging from 1 (*No Significant Effect*) to 9 (*Highly Detrimental Effect*), was used. The identified design problems surveyed are listed in Table 2.3.

Table 2.3 Identified Design Problems

Identified Design Problems
a) Inadequate or insufficient design work carried out
b) Design not being achievable with in the project budget
c) Insufficient clearances (from statutory bodies) prior to commencement on site
d) Designers with a lack of understanding of the project delivery process

e) Designers with a lack of knowledge of local by–laws or BCA requirements
f) Fast–track design not keeping pace with construction activities
g) Insufficient design coordination causing clashes between building elements
h) Insufficient design coordination causing clashes between services elements
i) Impractical construction methodologies and detailing
j) Site constraints not being adequately checked prior to starting on site
k) Materials or products specified contrary to manufacturers' recommendations
l) Limits being placed on the number or type of suppliers allowed
m) Lack of innovation in design solutions provided
n) Design changes causing disruption to critical construction activities

In Figure 2.17 below, the responses for the perceived frequency of occurrence for each of the identified design problems are shown. The chart has been arranged with the least occurring problem being at the top, whilst the problem occurring most frequently is at the bottom.

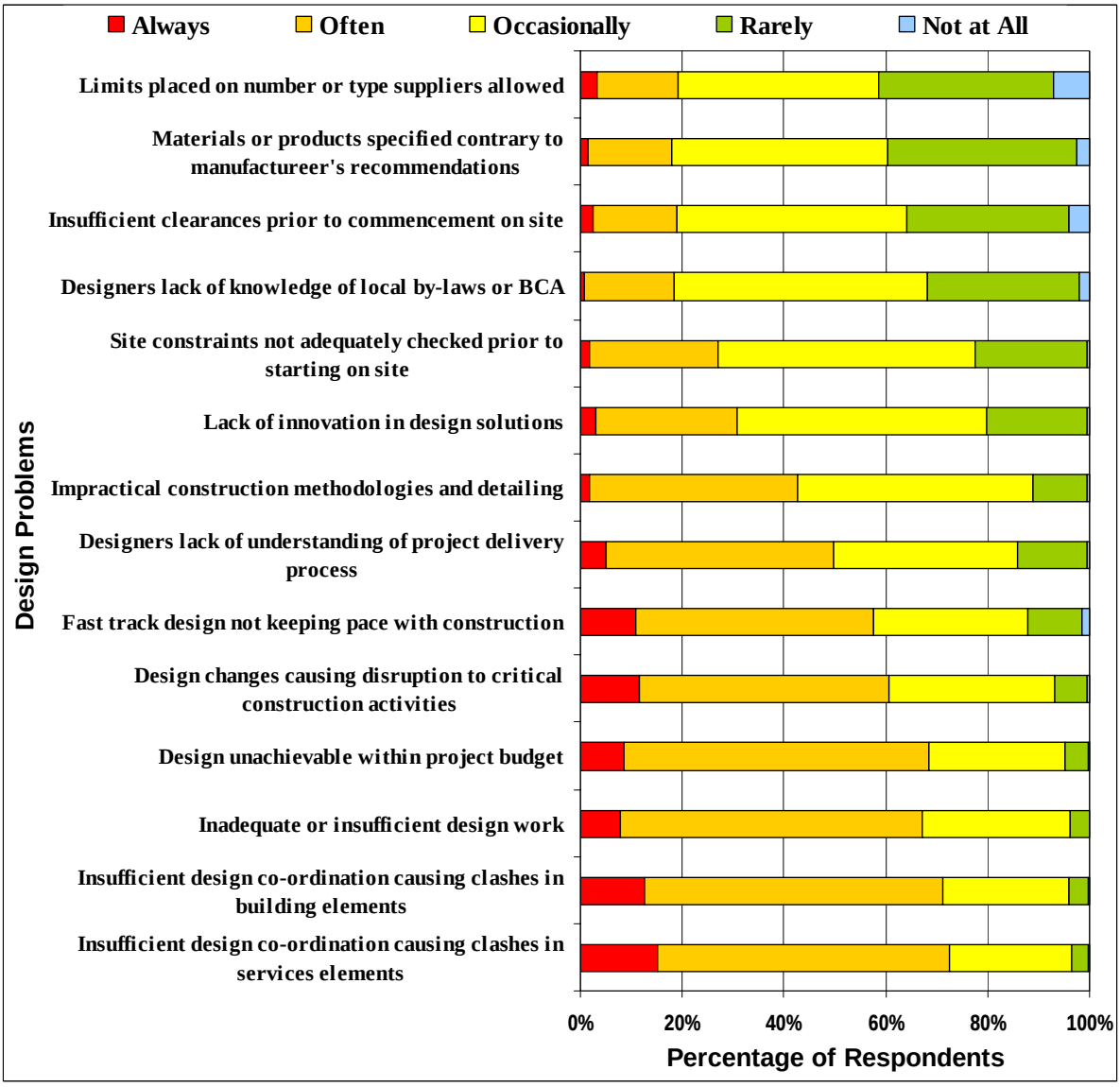


Figure 2.17 Frequency of occurrence of identified design problems

As can be seen in Figure 2.17 approximately half the issues raised, are perceived to occur with a high level of frequency by a large proportion of the respondents. Those issues that were perceived to have occurred most frequently were identified as:

- Insufficient design coordination causing clashes between services elements;
- Insufficient design coordination causing clashes between building elements;
- Inadequate or insufficient design work carried out; and
- Design not being achievable with in the project budget.

Those issues that occurred least frequently were identified as:

- Limits being placed on the number or type of suppliers allowed;
- Materials or products specified contrary to manufacturers' recommendations; and
- Insufficient clearances (from statutory bodies) prior to commencement on site.

Contractors were then asked to consider the level of detrimental effect that these problem areas have on construction process efficiency when they occur. The mean responses given, are shown in Figure 2.18.

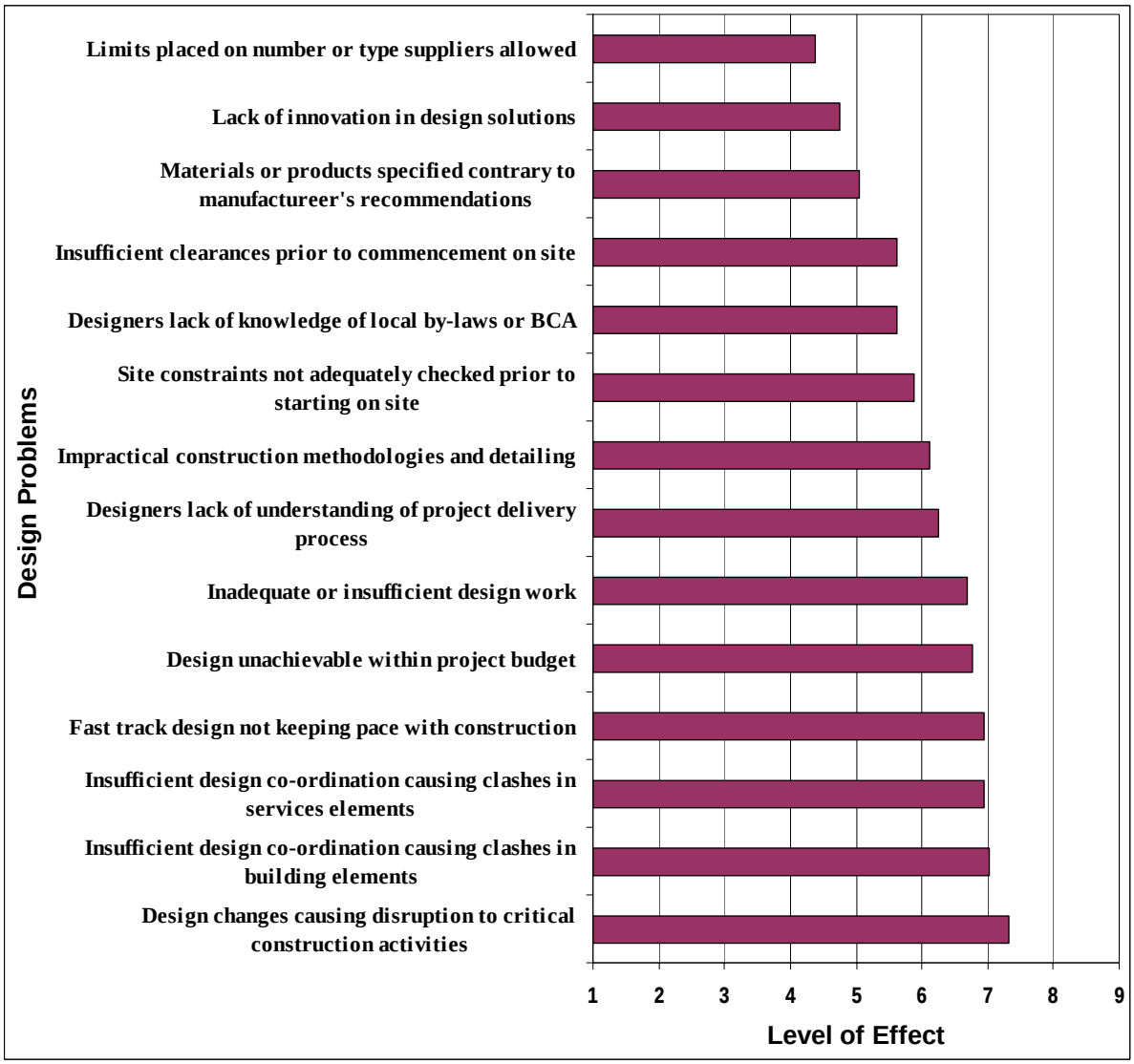


Figure 2.18 Level of effect of identified design problems on construction process efficiency

As was to be expected, all design problem areas were considered by the contractors to have some detrimental effect on construction process efficiency, however some areas were seen to have a much greater impact than others. The design problems that were seen to have the most effect on construction process efficiency were indicated as being:

- Design changes causing disruption to critical construction activities;
- Insufficient design coordination causing clashes between building elements;
- Insufficient design coordination causing clashes between services elements; and
- Fast–track design not keeping pace with construction activities.

The design problems that were seen to have the least effect on construction process efficiency were indicated as being:

- Limits being placed on the number or type of suppliers allowed;
- Lack of innovation in design solutions provided; and
- Materials or products specified contrary to manufacturers' recommendations.

As can be seen, even the design problems which were indicated to have the least effect, still have a significantly high detrimental effect on construction process efficiency.

When we compare Figure 2.17 and Figure 2.18, we find that the issues that occur most often are also the issues that appear to have the greatest detrimental effect on construction process efficiency. Figure 2.19 below graphically illustrates the results.

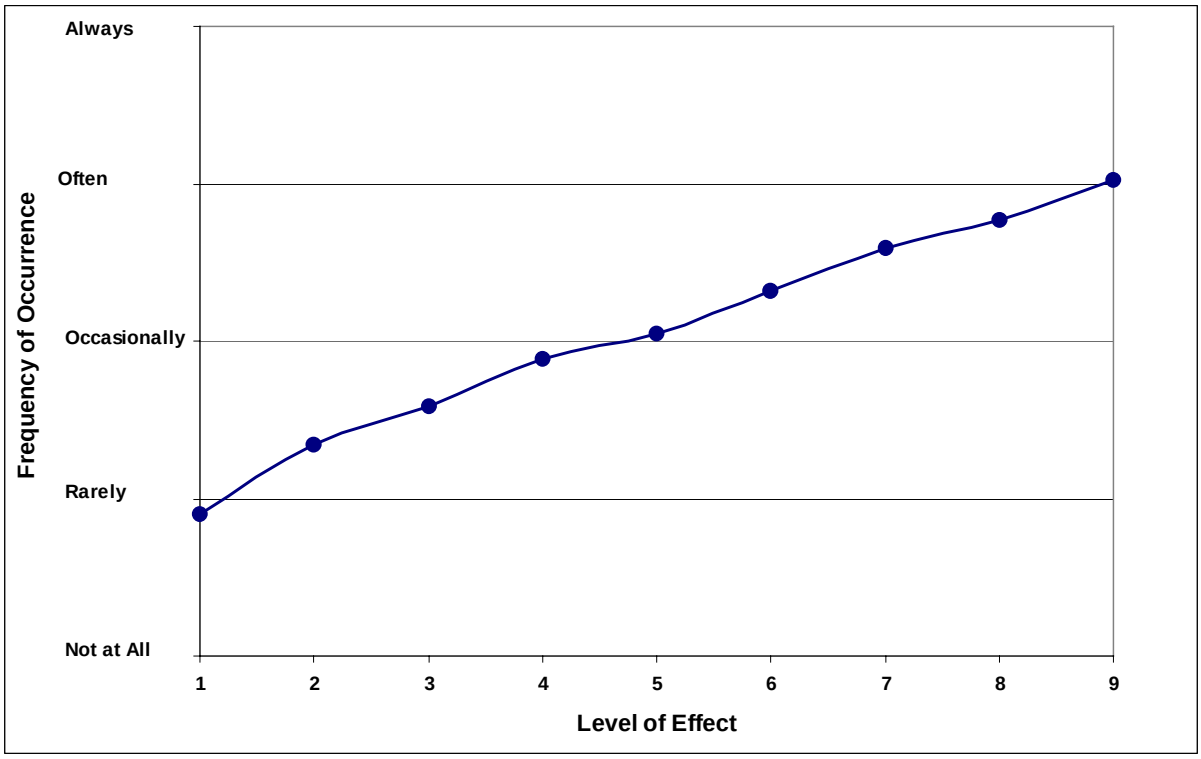


Figure 2.19 Correlation of frequency with effect for design deficiency issues

When a correlation analysis is carried out, the results show a statistical relationship between frequency and effect of 0.56, which indicates a moderately positive relationship.

Factors that were statistically significant for this question with regard to frequency were *State*, *Years*, *Size* and *Q.A.*. Those factors of statistical significance for effect were *Size* and *E-mail*. All factor interactions were significant excluding the interactions between *E-mail* and *Field*,

and *E-mail* and *Q.A.*. However, as previously, the differences in the responses for the various factors are only small and do not impact on the overall results.

2.2.3 Question 2.2 – Determination of whether there has been an increase in the overall frequency of occurrence of the identified design problems as a whole.

Having looked at the current frequency and effect of the identified design problems, Question 2.2 asked the respondents to determine whether or not there has been an increase in the overall frequency of occurrence of these problems as a whole, over the past 15 years, with the available responses being either:
a) *Yes*; b) *No*; or c) *Unsure*.

As can be seen in Figure 2.20 below, the vast majority (85%) of the respondents agreed that the frequency of occurrence of the identified design problems as a whole, has increased over the past 15 years. This left 12% of the respondents indicating that there had not been an increase, with the remaining 3% of respondents being unsure.

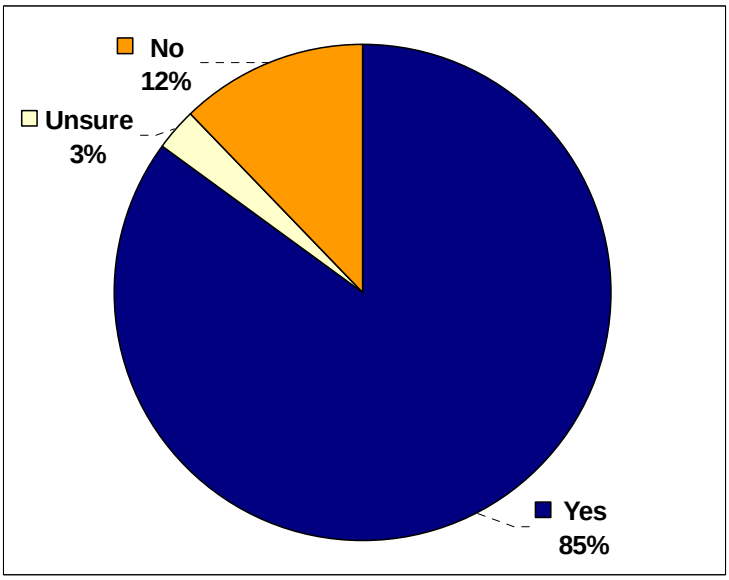


Figure 2.20 Response to whether there had been an increase in the frequency of design problems over the past 15 years – total

When checking the results across contracting groups, it was found that there was generally a high level of agreement among the contractor associations, that there had been an increase in the frequency of occurrence of design problems over the past 15 years (see Figure 2.21).

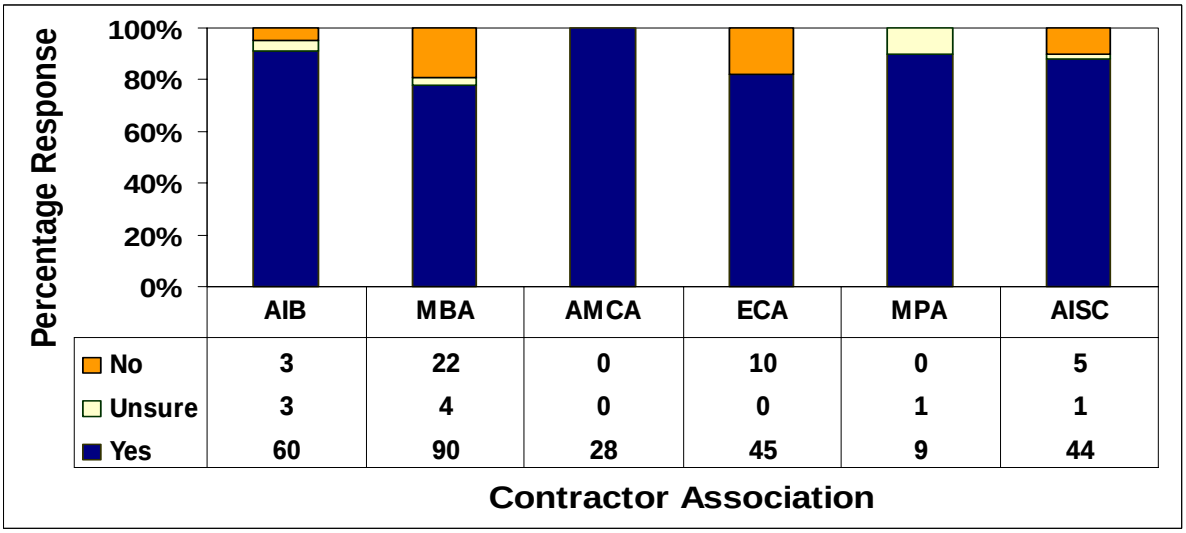


Figure 2.21 Response to whether there had been an increase in the frequency of design problems over the past 15 years – by contractor association

While a positive response was expected for this question – based on the results of section 1 – it was not to the degree indicated, especially with respect to the members of the AMCA, where all of the respondents answered "*Yes*". In contrast, the members of the MBA were the least sure, but 77% still claimed that there had been an increase.

2.2.4 Question 2.3 – Effect of different procurement systems on the overall quality of design being produced over the past 15 years.

In Question 2.3, the contractors were asked to rate their perception of the overall *quality* of design produced under three different procurement methodologies – *Traditional*, *Design and Construct* and *Management* procurement methods – at three different time periods – *Now, 5 – 7 Years Ago* and *12 – 15 Years Ago*. The level of quality was measured on a nine-point scale, from 1 (*Very Poor*) to 9 (*Excellent*). In Figure 2.22 below, the responses to this question graphically display the changes in overall design quality for each procurement method over the past 15 years.

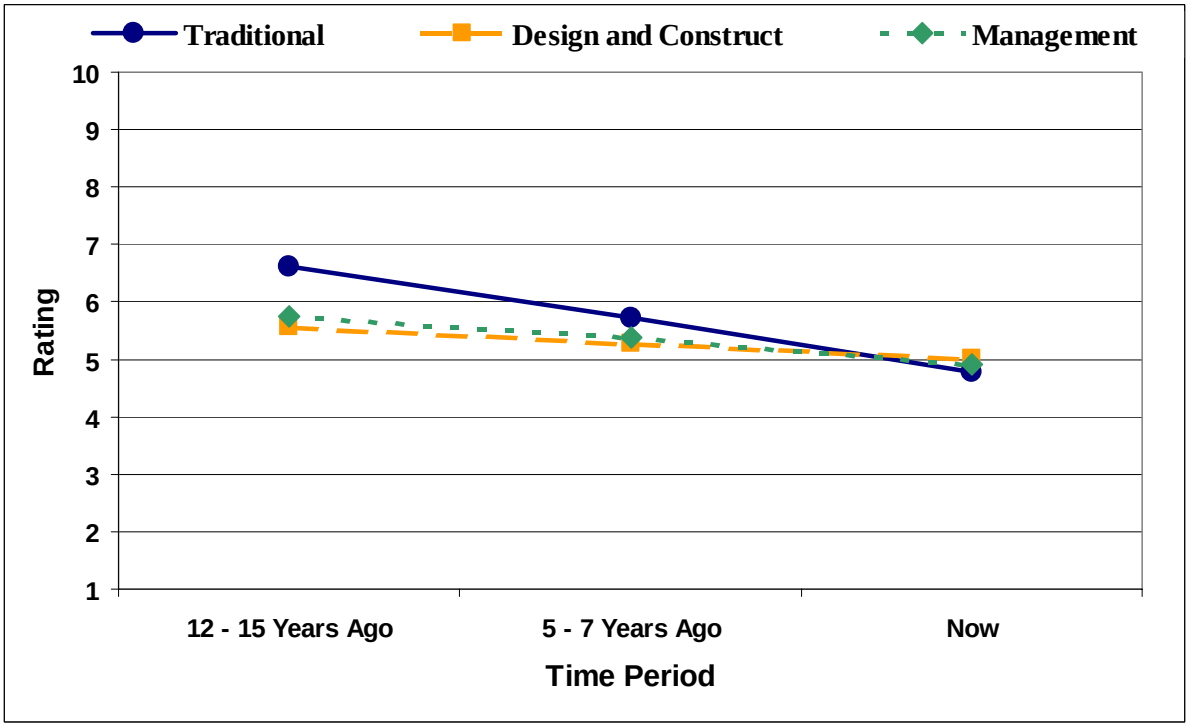


Figure 2.22 Ratings for overall design quality for each procurement method

These results highlight the contractor's perception that under each of the procurement methodologies, there has been a decline in overall design quality and that the level of decline has been greatest for the *traditional* procurement method. Although starting at a much higher rating 12 – 15 years ago, the rating for the *traditional* procurement method has now dropped below the standard of the other two procurement methods. Under both the *design and construct* and *management* procurement methods, overall design quality was rated similarly at each time period and was perceived to have declined to a much lesser degree than the *traditional* method.

From the information provided in Question 4.4 of the survey, it was possible to determine the proportion of the total turnover attributed to each procurement method for the 1997 – 1998 financial year (see Figure 2.44). With 44% of total turnover being attributable to the *traditional* procurement method, the perceived decline in quality under this method is considered even more significant. These responses confirm the contractor's perception shown in Question 1.2 while also providing an indication of the extent of the decline. However, it is disturbing to note that the rate of decline shown is linear, suggesting that a continuation of this decline is expected by the respondents.

2.2.5 Question 2.4 – Frequency of occurrence and level of effect of issues pertaining to documentation deficiency.

Question 2.4 looks at a number of documentation problem areas – previously identified at the contractor's workshop – and looks at determining not only how frequently they occur, but also what level of effect they have on construction process efficiency, when they occur. To measure the frequency of occurrence of each problem area, a five point rating scale – ranging from *Not at all* to *Always*, was used. However, to measure the level of effect, a nine point rating scale – ranging from 1 (*No Significant Effect*) to 9 (*Highly Detrimental Effect*), was used. The identified documentation problems surveyed are listed in Table 2.4.

Table 2.4 Identified Documentation Problems

Identified Documentation Problems
a) Documents issued with conflicting information
b) Documents lacking clarity and forcing contractors to interpret requirements
c) Late production of colour and finishes schedules
d) Documents issued with incorrect or inaccurate information
e) Critical explanatory notes hidden in general notes
f) Simple projects being unnecessarily over documented
g) Lack of definition and clarity in scope of works
h) Documents lacking standard details (reinventing the wheel)
i) Documents issued with insufficient details or dimensions
j) Inaccurate or non-standard or poorly prepared Bills of Quantities
k) Mixing of prescriptive and performance specification clauses
l) Issue of unamended standard specifications (Natspec/other projects)
m) Documents considered questionable in relation to project requirements
n) Reliance of specification notes, in areas where drawings are required
o) Documents calling up out–of–date or inappropriate standards/specifications
p) Specifications not designed to be split up into trade packages
q) Lack of programming to indicate the issue of critical design information
r) Use of catch all type clauses, requiring the contractor to make allowance for items not designed or specified

In Figure 2.23 below, the responses for the perceived frequency of occurrence for each of the identified documentation problems are shown. The chart has been arranged with the least occurring problem being at the top, whilst the problem occurring most frequently is at the bottom.

As can be seen, it is the opinion of a large proportion of the respondents that all the issues raised occur with a high level of frequency. Those issues that were perceived to have occurred most frequently were identified as:

- Use of catch all type clauses, requiring the contractor to make allowance for items not designed or specified;
- Documents lacking clarity and forcing contractors to interpret requirements;
- Documents issued with insufficient details or dimensions; and
- Documents issued with conflicting information.

Those issues that occurred least frequently were identified as:

- Simple projects being unnecessarily over documented;
- Specifications not designed to be split up into trade packages; and
- Documents calling up out–of–date or inappropriate standards/specifications.

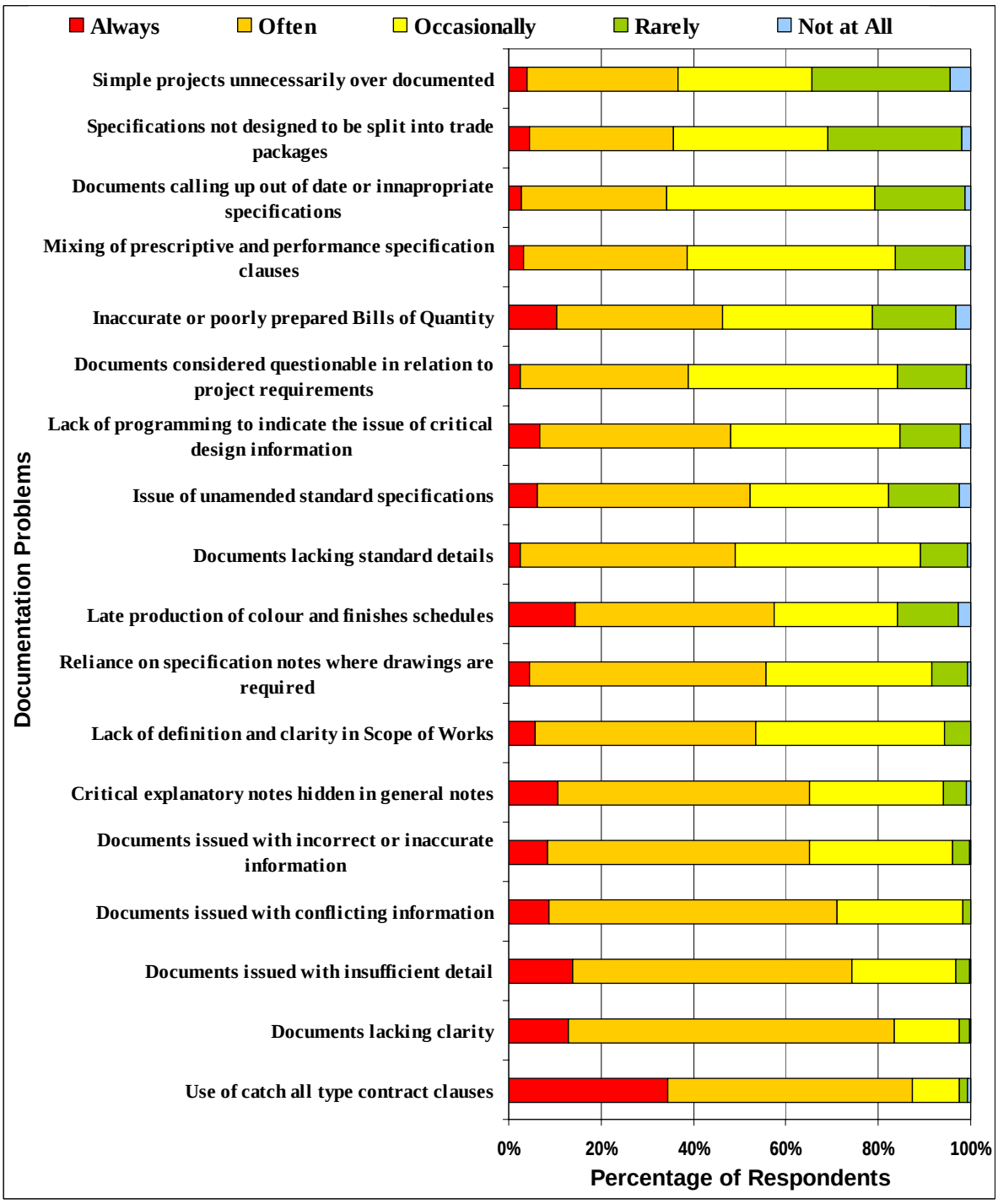


Figure 2.23 Frequency of occurrence of identified documentation problems

Contractors were then asked to consider the level of detrimental effect that these problem areas have on construction process efficiency when they occur. The mean responses given, are shown in Figure 2.24.

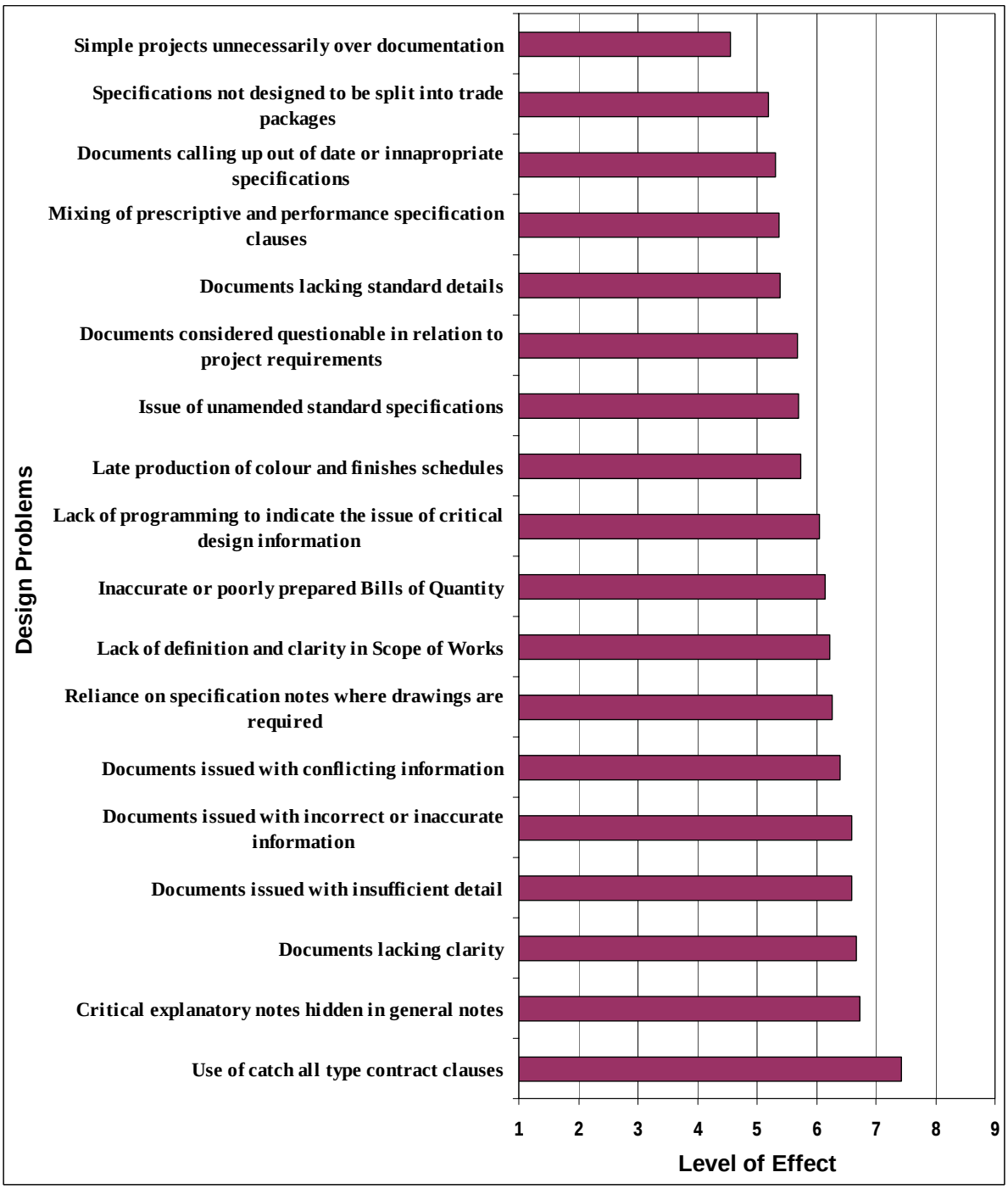


Figure 2.24 Level of effect of identified documentation problems on construction process efficiency

As was to be expected, all documentation problem areas were considered by the contractors to have some detrimental effect on construction process efficiency, however some areas were seen to have a much greater impact than others. The documentation problems that were seen to have the most detrimental effect on construction process efficiency were indicated as being:

- Use of catch all type clauses, requiring the contractor to make allowance for items not designed or specified;
- Critical explanatory notes hidden in general notes;
- Documents lacking clarity and forcing contractors to interpret requirements; and
- Documents issued with insufficient details or dimensions.

The documentation problems that were seen to have the least effect on construction process efficiency were indicated as being:

- Simple projects being unnecessarily over documented;
- Specifications not designed to be split up into trade packages; and
- Documents calling up out–of–date or inappropriate standards/specifications.

As can be seen, even the documentation problems which were indicated to have the least effect, still have a significantly high detrimental effect on construction process efficiency.
The issues that were perceived to occur most frequently and have the greatest detrimental effect were indicated as being:

- Use of ***catch all*** type clauses, requiring the contractor to make allowance for items not designed or specified;
- Documents lacking clarity and forcing contractors to interpret requirements;
- Documents issued with insufficient details or dimensions; and
- Documents issued with incorrect or inaccurate information,

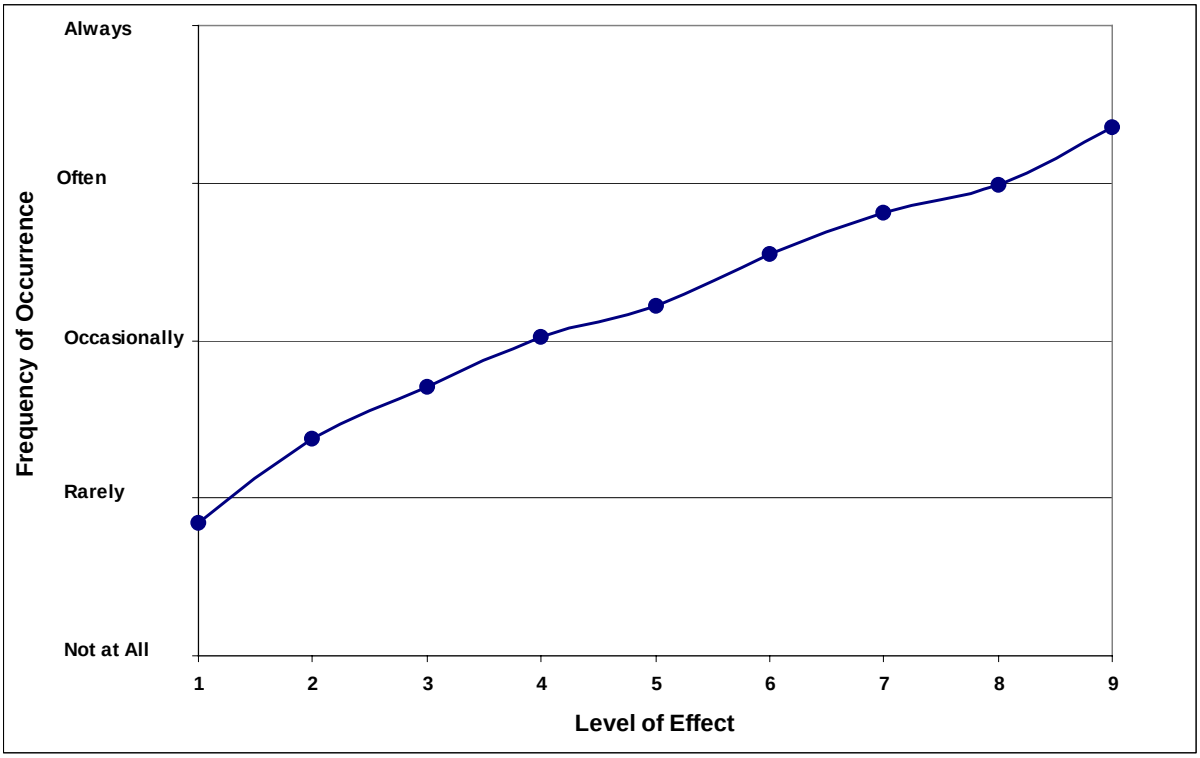


Figure 2.25 Correlation of frequency with effect for documentation deficiency issues

Figure 2.25 illustrates that the issues that occur most often are also the issues that appear to have the greatest detrimental effect on construction process efficiency. When a correlation analysis is carried out, the results show a statistical relationship between frequency and effect of 0.62, which indicates a moderate to strong relationship.

Factors that were statistically significant for this question with regard to frequency were *Field*, *State*, and *Q.A.*. Those factors of statistical significance for effect were *Field* and *Size*. All factor interactions were significant excluding the interactions between *E-mail* and *Field*, and *E-mail* and *State*. However, as previously, the differences in the responses for the various factors are only small and do not impact on the overall results.

When the results for both design and documentation problems were compared, it appears that although the documentation problems occur more frequently than the design problems, the level of effect on construction process efficiency was on average, generally the same.

2.2.6 Question 2.5 – Determination of whether there has been an increase in the overall frequency of occurrence of the identified documentation problems as a whole.

Having looked at the current frequency and effect of the identified documentation problems, Question 2.5 asked the respondents to determine whether or not there has been an increase in the overall frequency of occurrence of these problems as a whole, over the past 15 years, with the available responses being either:
a) *Yes*; b) *No*; or c) *Unsure*.

As can be seen in Figure 2.26 below, the vast majority (92%) of the respondents agreed that the frequency of occurrence of the identified documentation problems as a whole, has increased over the past 15 years. This left 5% of the respondents indicating that there had not been an increase, with the remaining 3% of respondents being unsure.

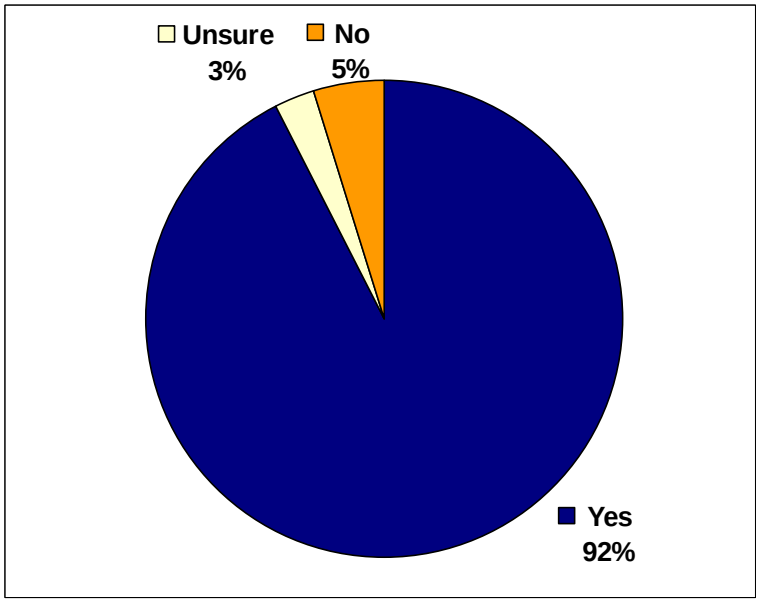


Figure 2.26 Response to whether there had been an increase in the frequency of documentation problems over the past 15 years – total

Again, a check of the results across the various contracting groups found that there was a high level of agreement among all the contractor associations, in relation to there having been an increase in the frequency of occurrence of documentation problems over the past 15 years (see Figure 2.27).

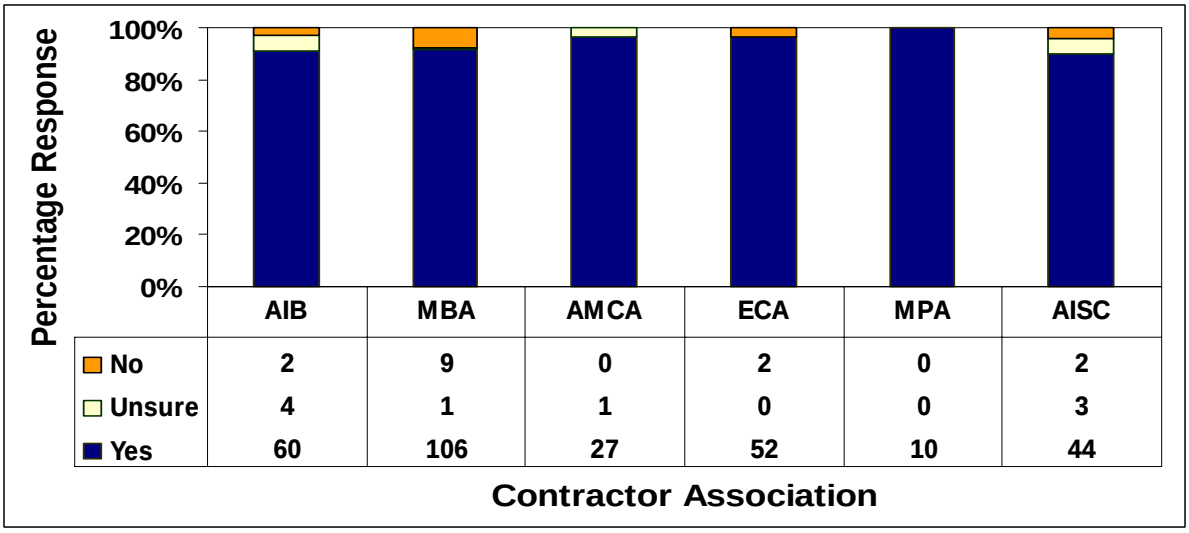


Figure 2.27 Response to whether there had been an increase in the frequency of documentation problems over the past 15 years – by contractor association

Just like in Question 2.2, a positive response was expected, but once again the degree of agreement indicated by the contractors was exceptionally high, with even the lowest level of agreement being at 90%.

2.2.7 Question 2.6 – Effect of different procurement systems on the overall quality of documentation being produced over the past 15 years.

In Question 2.6, the contractors were asked to rate their perception of the overall *quality* of documentation produced under three different procurement methodologies – *Traditional*, *Design and Construct* and *Management* procurement methods – at three different time periods – *Now*, *5 – 7 Years Ago* and *12 – 15 Years Ago*. The level of quality was measured on a nine-point scale, from 1 (*Very Poor*) to 9 (*Excellent*). In Figure 2.28 below, the responses to this question graphically display the changes in overall design quality for each procurement method over the past 15 years.

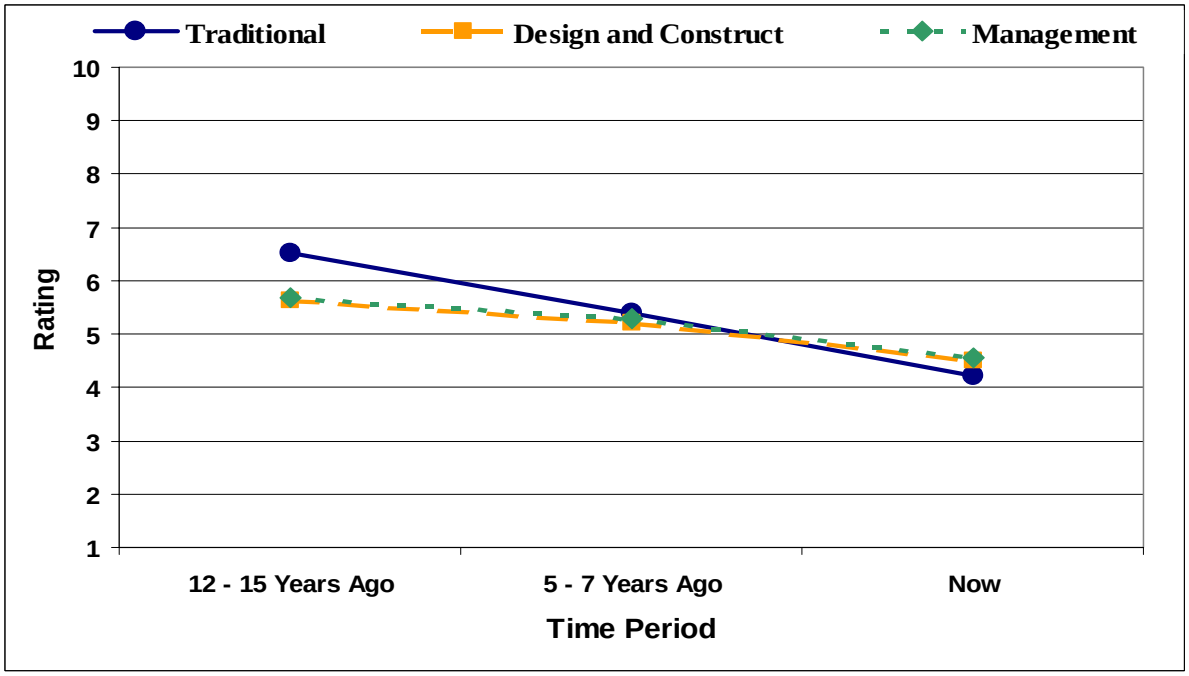


Figure 2.28 Ratings for overall documentation quality for each procurement method

Just like in Question 2.3, these results highlight the contractor's perception that under each of the procurement methodologies, there has been a decline in overall documentation quality and that the level of decline has been greatest for the *traditional* procurement method. Although starting at a much higher rating 12 – 15 years ago, the rating for the *traditional* procurement method has now dropped below the standard of the other two procurement methods. Under both the *design and construct* and *management* procurement methods, overall documentation quality was rated similarly at each time period and was perceived to have declined to a much lesser degree than under the *traditional* method.

Again comparing these results with those of Question 2.3, it can be seen that the level of decline in overall documentation quality has been greater than the decline in overall design quality, under all procurement methodologies. These results also confirm the responses to Question 1.6, where 82% of the respondents agreed that the decline in documentation quality had been greater than the decline in design quality.

When we assess the results shown in Question 2.3 and Question 2.6, it is fair to conclude that it is the contractors' overall belief that the current standard of design and documentation is rated on average, between "*average*" and "*poor*", with documentation quality being much closer to "*poor*". With the level of decline showing no signs of changing, designers will need to take drastic action to reverse the trend and restore confidence within the contracting groups.

2.3 Section 3 – The nature and extent of the impact of design and documentation deficiency on construction process efficiency (CPE).

2.3.1 Section 3 – Overview

This section deals with trying to quantify the extent to which design and documentation deficiency affects the efficiency of the construction process. This is achieved by firstly looking at the impact that different levels of design and documentation quality have on project time and cost estimates, at tender stage. Having determined this, the respondents are then asked to consider a number of undesirable elements of construction and determine:

- what proportion are as a direct result of design and documentation deficiencies;
- to what extent have their occurrences changed over the past 15 years; and
- to what extent has the administrative time and cost required to deal with them, changed over the past 15 years.

The nature and extent of the impact of design and documentation deficiencies on construction process efficiency indicators are clear – additional project cost and time. The results indicate that almost all contractors add an additional percentage margin to both the tender price submitted for a project and the time allowed to complete a project, to compensate for poor quality design and documentation. The extent of this additional allowance is generally determined by the perceived standard of design and documentation provided – the worse the quality standard, the greater the additional allowance. Based on the current average standard of design and documentation being rated between "*average*" and "*poor*", the respondents have indicated that an average additional allowance of between 2.5% and 7.2% is being added to both the submitted tender price and the time to complete for new projects.

When asked to consider a number of undesirable elements of construction on work currently being carried out, the respondents indicated that design and documentation deficiency was considered to be directly responsible for a high proportion of these problems. Requests for information (RFIs) and variations were particularly of note, but all areas identified contributed. When asked to consider how the extent of occurrence of these undesirable elements of construction had changed over the past 15 years, the contractors indicated an overall average increase of around 50% within that time period.

Similarly, the managerial time and cost expended on these problem areas has also increased over the same time period. When asked to consider both the managerial and/or administrative time and cost expended on each problem area, the contractor's responses indicated an increase of more than 100% in both time and cost to look after these issues over the past 15 years.

2.3.2 Question 3.1 – Determine whether the quality of design and documentation supplied has an influence on the tender price submitted.

In Question 3.1, contractors were asked to determine whether or not the quality of design and documentation supplied on a project, has an influence on the tender price submitted – with the available responses being either:
a) *Yes*; b) *No*; or c) *Unsure*.

As can be seen in Figure 2.29 below, the vast majority (93%) of the respondents agreed that the quality of design and documentation influenced the tender price submitted. This left 4% of the respondents indicating that design and documentation quality did not influence the tender price submitted, with the remaining 3% of respondents being unsure.

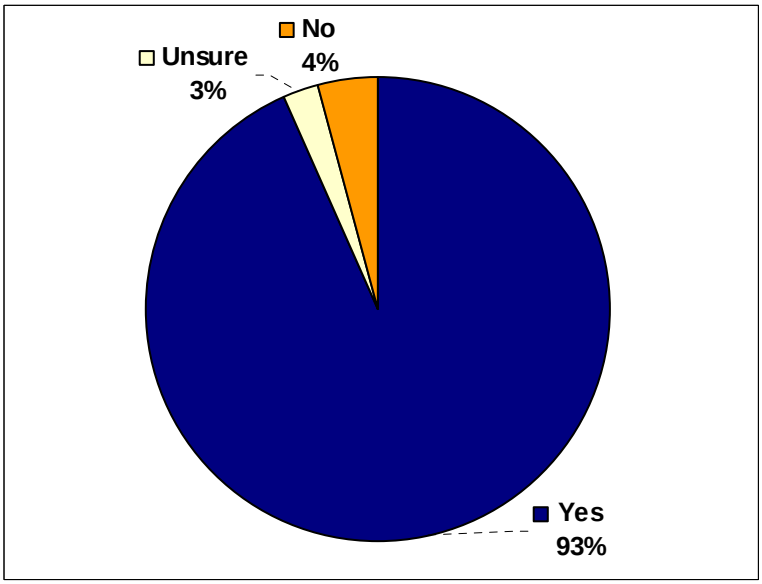
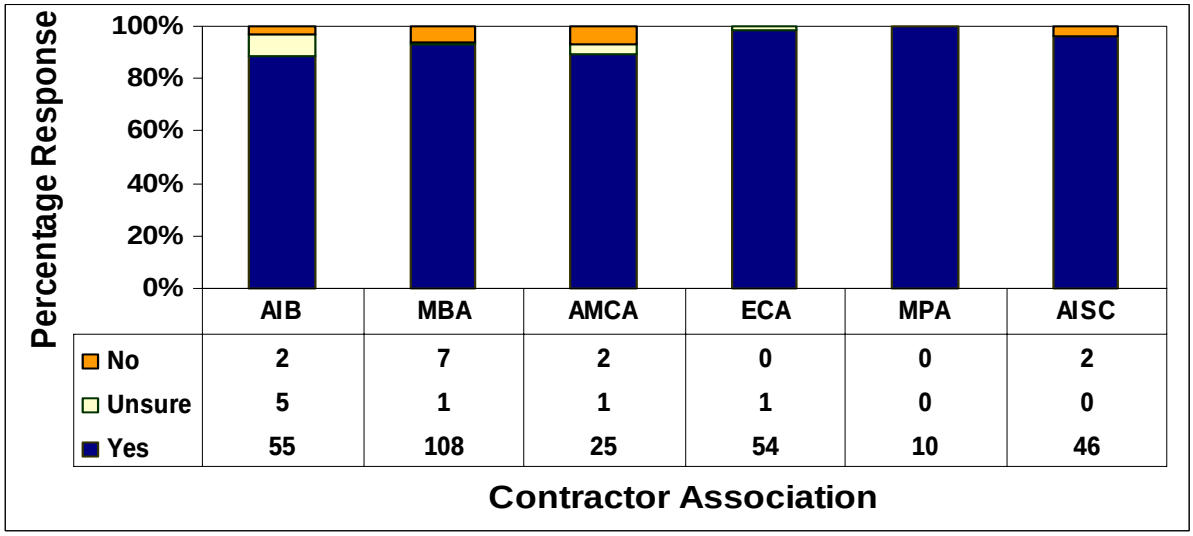


Figure 2.29 Response to whether the quality of design and documentation influenced the tender price submitted – total

As expected, when checking the results across the contracting groups, it was found that the level of agreement between them all was also very high (see Figure 2.30).



	AIB	MBA	AMCA	ECA	MPA	AISC
No	2	7	2	0	0	2
Unsure	5	1	1	1	0	0
Yes	55	108	25	54	10	46

Figure 2.30 Response to whether the quality of design and documentation influenced the tender price submitted – by contractor association

2.3.3 Question 3.2 – Determine to what degree the quality of design and documentation supplied influences the tender price submitted.

Having determined whether the quality of design and documentation influenced the tender price submitted on a project, the purpose of Question 3.2 was to determine to what extent the project cost estimate was influenced. The question provided contractors with five design and documentation quality levels – from *very poor* to *excellent* – and asked them to indicate what percentage reduction or increase to the project tender price would be allowed for each specific standard.

As can be seen in Figure 2.31, an analysis of the contractors' responses indicates that as the standard of design and documentation deteriorates, the tender price submitted for a project increases considerably.

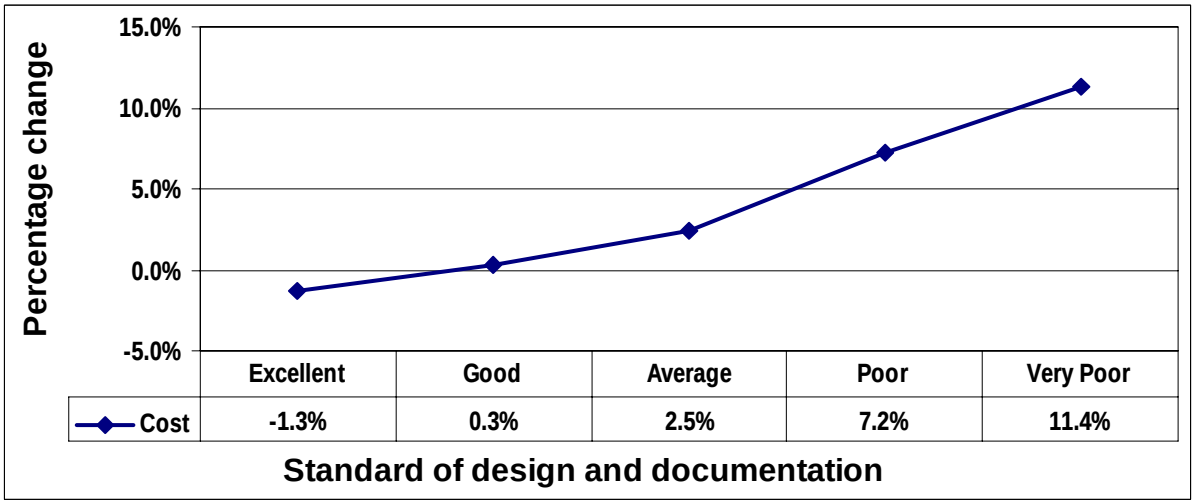


Figure 2.31 Change in tender price relative to the standard of design and documentation quality

As indicated in Section 2, it is the contractors' belief that the current average standard of design and documentation is rated between "*average*" and "*poor*". Based on these conclusions, it can be seen that an average additional allowance of between 2.5% and 7.2% is being included in the submitted tender price for most current new projects – a cost mostly being borne by clients and developers. Although contractors indicated that a small allowance for possible problems was still added to the tender price when the standard of design and documentation was rated as good, they also indicated that should design and documentation quality be rated as excellent, then significant cost reductions would occur.

Further analysis was carried out to see if there were any significant differences between the allowances being made by head contractors when compared to those being made by trade contractors. As can be seen in Figure 2.32, the quality of design and documentation has a greater impact on the tender prices submitted by trade contractors than by head contractors.

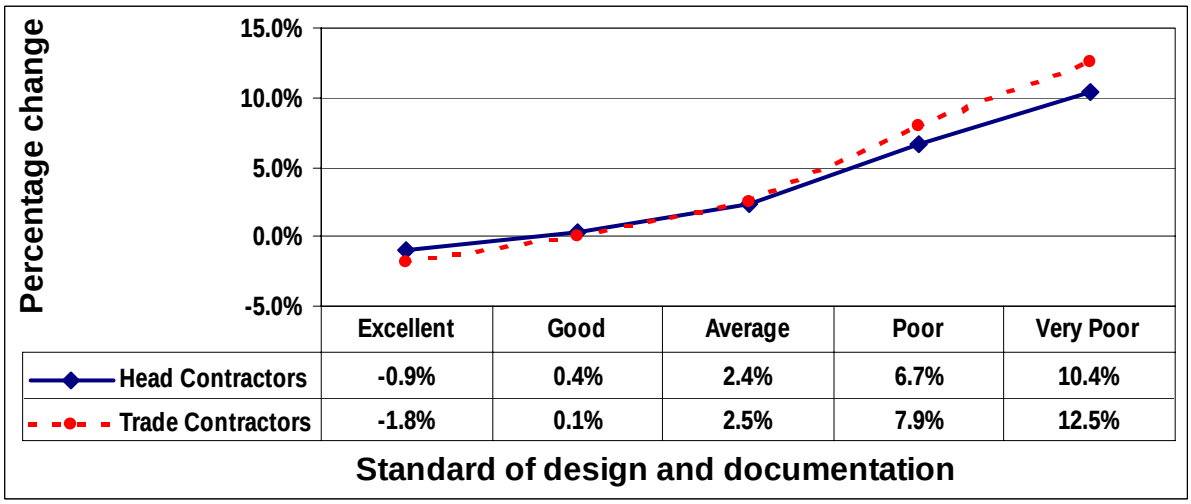


Figure 2.32 Change in tender price relative to the standard of design and documentation quality – comparison between head and trade contractors

To check the extent of the negative relationship between the standard of design and documentation and the price submitted for a project, a correlation analysis was carried out.

This analysis provided a correlation statistic of -0.76, which indicates a strong negative relationship between design and documentation quality and the price submitted for a project.

Other factors that were statistically significant were *Years*, *Size* and *Q.A.*. All interactions between the factors were also significant except those interactions involving *E-mail*, however no individual factors or interactions were considered noteworthy.

2.3.4 Question 3.3 – Determine whether the quality of design and documentation supplied has an influence on the project time allowance.

In Question 3.3, contractors were also asked to determine whether or not the quality of design and documentation supplied on a project, had an influence on the project time allowance included in the project tender estimate – with the available responses being either:
a) *Yes*; b) *No*; or c) *Unsure*.

As can be seen in Figure 2.33 below, a large proportion (75%) of the respondents agreed that the quality of design and documentation influenced the project time allowance included within the tender estimate. This left 18% of the respondents indicating that design and documentation quality did not influence the tender price submitted, with the remaining 7% of respondents being unsure.

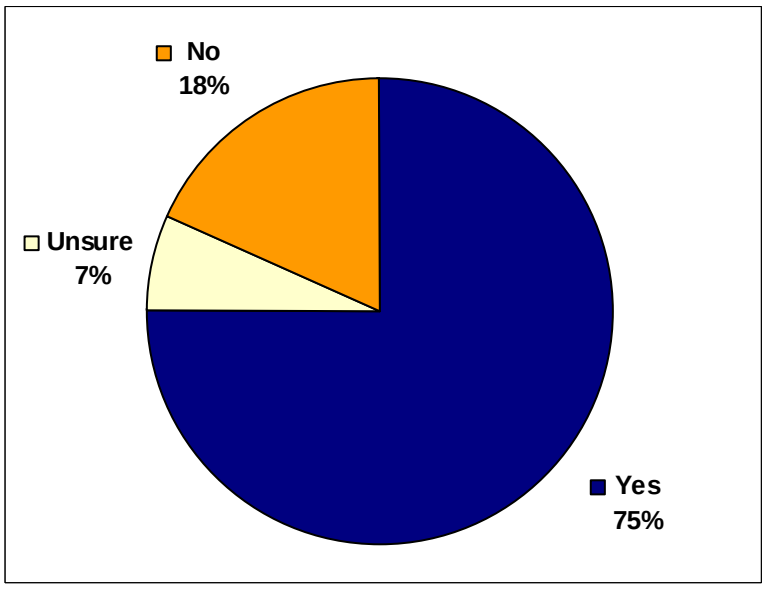


Figure 2.33 Response to whether the quality of design and documentation influenced the project time allowance – total

However, when checking the results across the contracting groups, it was found that there was a significant difference in opinion between the head contractors and trade contractors. As can be seen in Figure 2.34, when we compare the two groups, only 66% of head contractors indicated that they modified the project time allowance due to design and documentation quality problems, compared to 87% of trade contractors. This may be due to design and documentation quality problems having a greater effect on the time allowance for individual trades, than on the overall project duration, which is commonly set by the client.

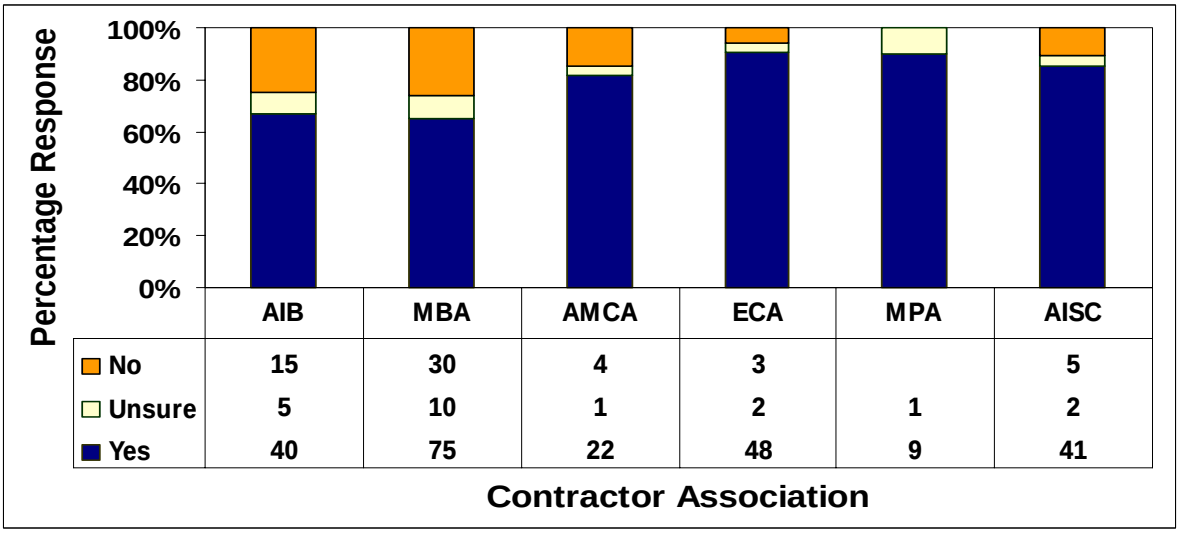


Figure 2.34 Response to whether the quality of design and documentation influenced the project time allowance – by contractor association

2.3.5 Question 3.4 – Determine to what degree the quality of design and documentation supplied influences the project time allowance.

Having determined whether the quality of design and documentation influenced the tender price submitted on a project, the purpose of Question 3.4 was to determine to what extent the project time allowance included in the tender estimate was influenced. The question provided contractors with five design and documentation quality levels – from *very poor* to *excellent* – and asked them to indicate what percentage reduction or increase to the project time allowance included in the tender estimate would be allowed for each specific standard.

As can be seen in Figure 2.35, an analysis of the contractors' responses indicates that as the standard of design and documentation deteriorates, the project time allowance included in the tender estimate for a project also increases considerably.

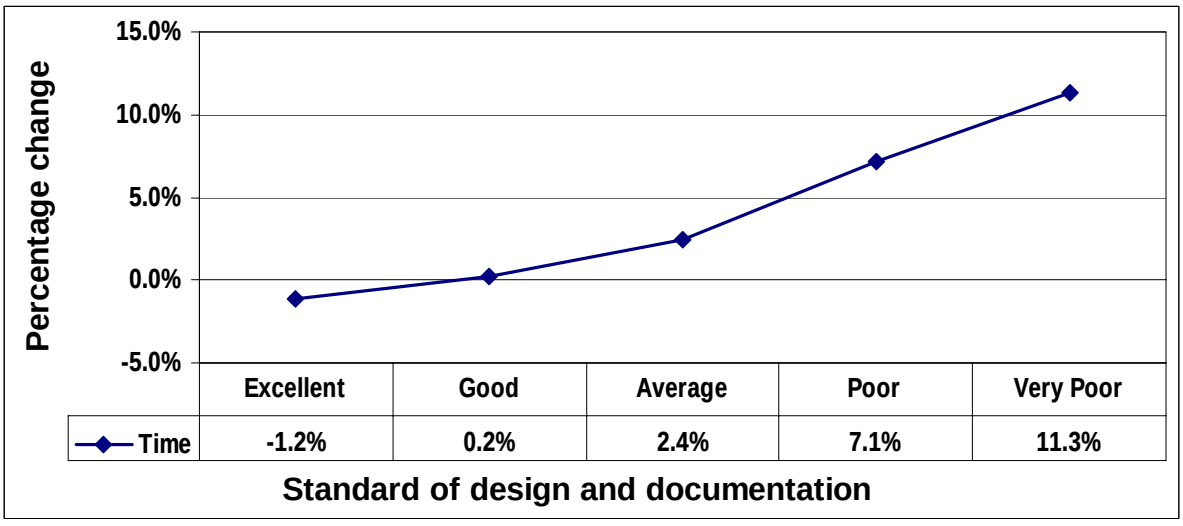
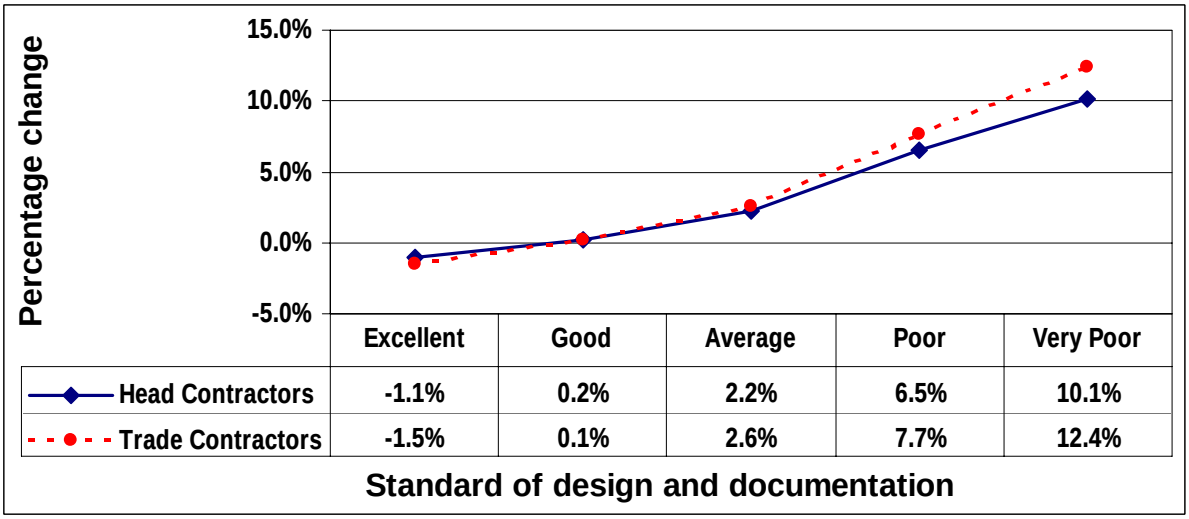


Figure 2.35 Change in project time allowed relative to the standard of design and documentation

In addition to the extra cost being included in tender estimates, an average additional allowance of between 2.4% and 7.1% is also being added to the project time allowance included in the tender estimate for the majority of new projects, based on the current average standard of design and documentation being rated between "*average*" and "*poor*". However,

as was the case with the tender *cost* estimates, should contractors rate design and documentation quality as excellent, then significant project time reductions would also occur.

To determine whether there were any significant differences between the allowances being made by head contractors when compared to those being made by trade contractors, further analysis was again carried out. As can be seen in Figure 2.36, the quality of design and documentation has a greater impact on the project time allowances included by trade contractors than by head contractors.



	Excellent	Good	Average	Poor	Very Poor
Head Contractors	-1.1%	0.2%	2.2%	6.5%	10.1%
Trade Contractors	-1.5%	0.1%	2.6%	7.7%	12.4%

Figure 2.36 Change in project time allowance relative to the standard of design and documentation quality – comparison between head and trade contractors

As with Question 3.2, a correlation analysis was carried out to determine the extent of the negative relationship between the standard of design and documentation and the project time allowance included in the tender estimate for a project. This analysis provided a correlation statistic of -0.73, which again indicates a strong negative relationship between design and documentation quality and the project time allowance included in the tender estimate.

Other factors that were statistically significant were *Field*, *State* and *Years*. Although all interactions between the factors were significant, no individual factors or interactions were considered noteworthy.

As can clearly be seen, the results shown in Question 3.2 are almost identical to those shown in Question 3.4. A correlation analysis of the percentage change in the tender price submitted and the project time allowed for a project – given a particular standard of design and documentation quality – indicated that if there was a change in one factor, then there was an equivalent change in the other. The resultant correlation statistic of 0.87, indicates a strong positive relationship between the two factors affected.

2.3.6 Question 3.5 – Proportion of non-desirable elements of construction considered to be as a direct result of design and documentation deficiencies.

To try to further determine how design and documentation deficiency affects the efficiency of the construction process, Question 3.5 asked contractors to consider a number of non-desirable elements of construction and determine what proportion of these elements were considered to be as a direct result of design and documentation deficiencies. The seven non-desirable elements listed are shown in Table 2.5.

Table 2.5 Non-desirable Elements of Construction

Non-desirable Elements of Construction
a) Rework
b) Programme delays
c) Extensions of time
d) Cost overruns
e) Variations
f) Contractual disputes
g) Requests for information (RFIs)

As can be seen in Figure 2.37, an analysis of the contractors' responses indicates that quite a large proportion of each non-desirable element listed, was seen as being directly attributable to deficiencies in the design and documentation provided to them.

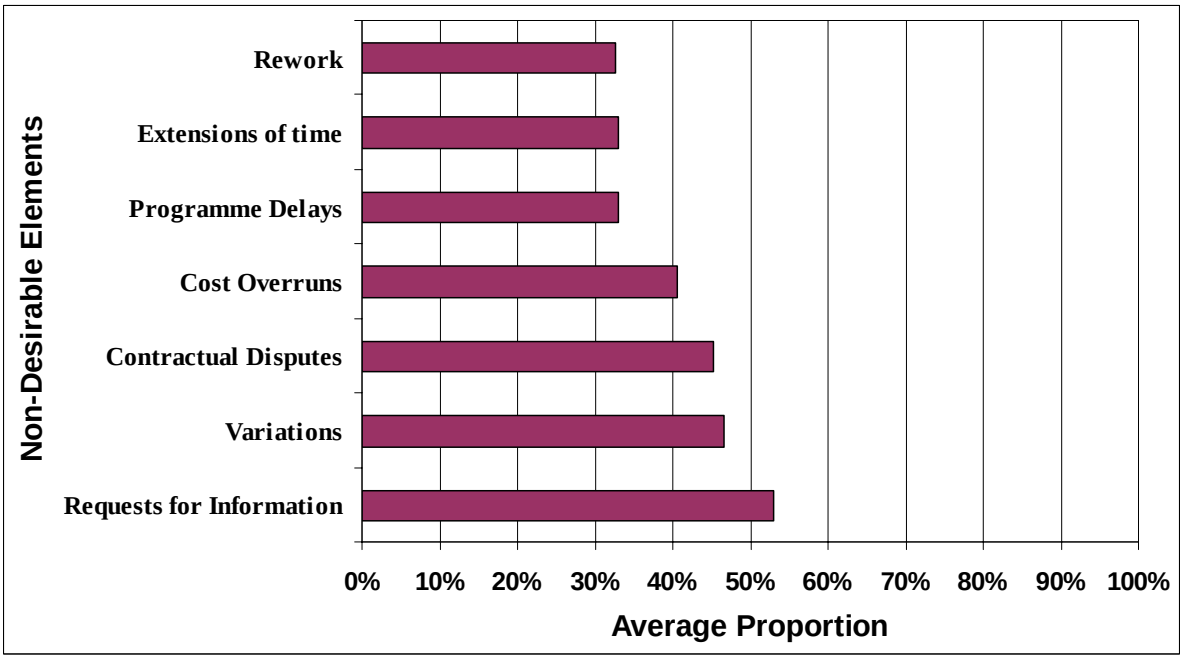


Figure 2.37 Average proportion of non-desirable elements of construction resulting directly from design and documentation deficiencies

As can be seen from the chart, contractors believe that more than half of all *requests for information* are due to design and documentation deficiencies, with more than 40% all *variations*, *contractual disputes* and *cost over runs* also due to the same cause.

The factors that were statistically significant for these issues were *Field* and *Size*. All the factor interactions were also statistically significant except for those between *Field* and *E-mail*. Although the extent of the differences for the *Field* factors were generally minor, it was noticeable that the responses from both the AMCA and ECA members across all non-desirable elements, were significantly lower than from the other groups.

2.3.7 Question 3.6 – Level of occurrence of non-desirable elements of construction over the past 15 years.

Having determined the proportion of non-desirable elements of construction that were directly attributable to design and documentation deficiencies, Question 3.6 asked contractors to consider how the extent of their occurrence has changed over the past 15 years. The extent of occurrence was measured on an eleven-point scale, from 0 (*Nil*) to 10 (*Extremely Excessive*).

In Figure 2.38 below, the changes that have occurred over the past 15 years in the extent of occurrence of the seven non-desirable elements listed, are graphically displayed.

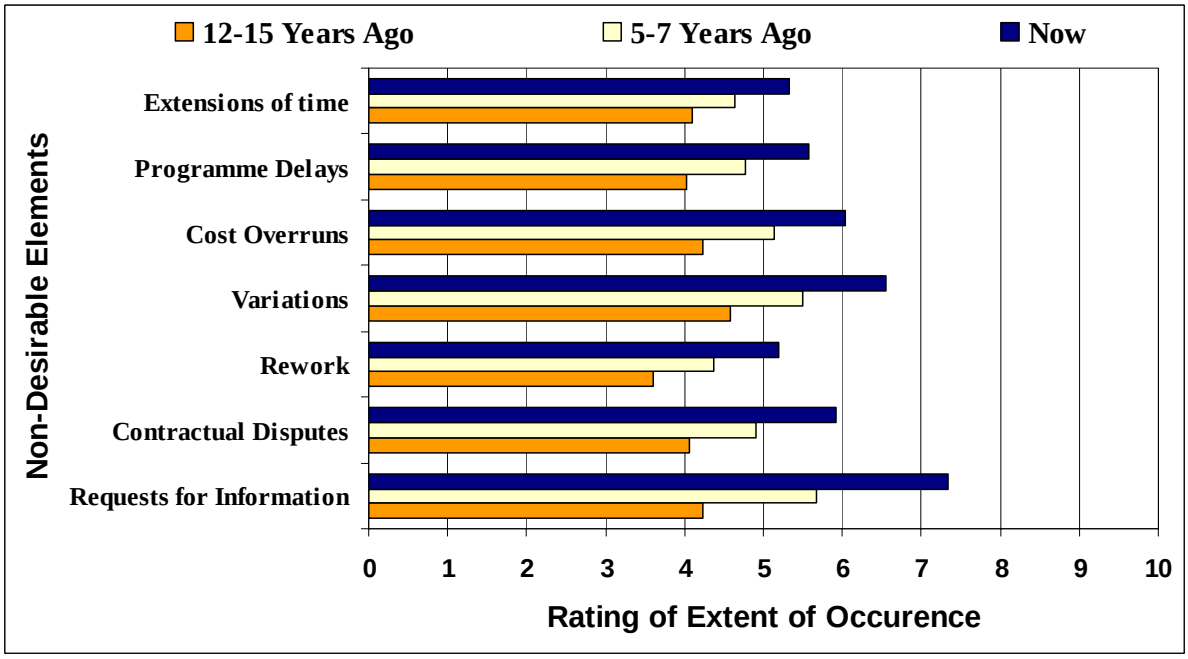


Figure 2.38 Changes in the extent of occurrence of non-desirable elements of construction over the past 15 years

As is clearly shown, contractors believe that the extent of occurrence of each of the non-desirable elements listed, has increased substantially over the past 15 years. The percentage increases in the extent of occurrences, range from 30.4% (*extensions of time*) to 73.7% (*requests for information*) over this period, with *requests for information* also currently rating the highest level of occurrence overall at 7.3 – a rating that contractors consider to be very excessive. Whilst the extent of these non-desirable elements may have been reasonably controllable 15 years ago, the substantial and continuing increase in their extent of occurrence must surely be impacting heavily on the efficiency of the construction process on a majority of new projects, across the industry.

Again, all factors and factor interactions were statistically significant for this question and while the level of significance varied for each of the elements and time periods, the magnitude of differences was only considered minor.

2.3.8 Question 3.7 – Proportion of managerial time and cost expended on non-desirable elements of construction over the past 15 years.

In Question 3.7, contractors were asked to consider how the extent of the managerial or administrative time and cost needed to manage these non-desirable elements of construction, has changed over the past 12 to 15 years. To measure this change, contractors were asked to select the percentage range – from *0 - 1%* to *+20%* – that represents the estimated amount of

both administrative time and cost expended at three different time periods, managing each of the non-desirable elements listed.

In Figure 2.39 below, the changes that have occurred over the past 12 to 15 years in the proportion of managerial or administrative time used to manage the seven non-desirable elements listed, are shown.

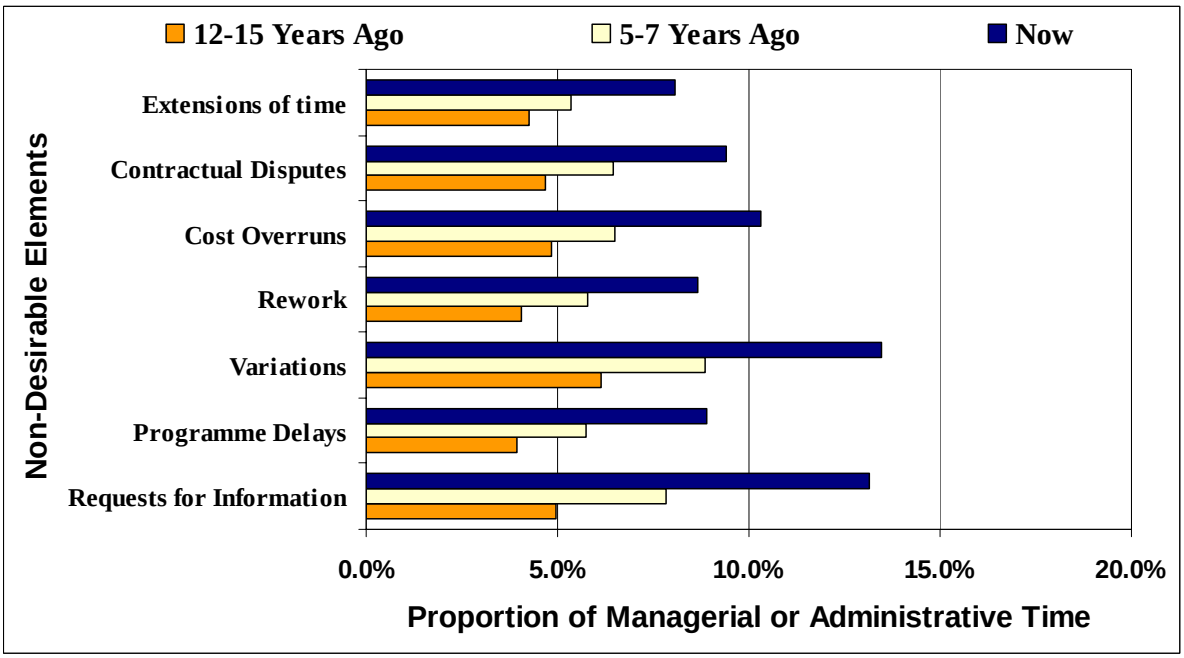


Figure 2.39 Average proportion of managerial or administrative *time* used in managing non-desirable elements of construction

As can clearly be seen, the total amount of managerial or administrative time spent on each of the non-desirable elements, has increased dramatically over the past 12 to 15 years. Based on the contractors' responses, the time spent looking after *extensions of time* has increased by an average of 89.3%, while the time spent on *requests for information* has increased by an average of 164.5%. Although *requests for information* have shown the greatest increase over the time period, *variations* now take up the most time, using up 13.5% of all managerial or administrative time allowed on a project.

When all the elements listed are considered together, the results indicate that the amount of time needed to effectively look after them all, 12 to 15 years ago, added to only approximately one third (32.9%) of the total amount of managerial or administrative time allowed on a project. Now however, the contractors have indicated that the time required to look after the same elements, requires over two thirds (72.0%) of all managerial or administrative time – an increase of 119.1%.

While knowing the amount of managerial or administrative time consumed by non-desirable elements of construction is vitally important, it is equally important to know the proportion of managerial or administrative cost that is expended looking after these same elements. In Figure 2.40 below, the changes that have occurred over the past 12 to 15 years in the proportion of managerial or administrative cost in the management of the seven non-desirable elements listed, are shown.

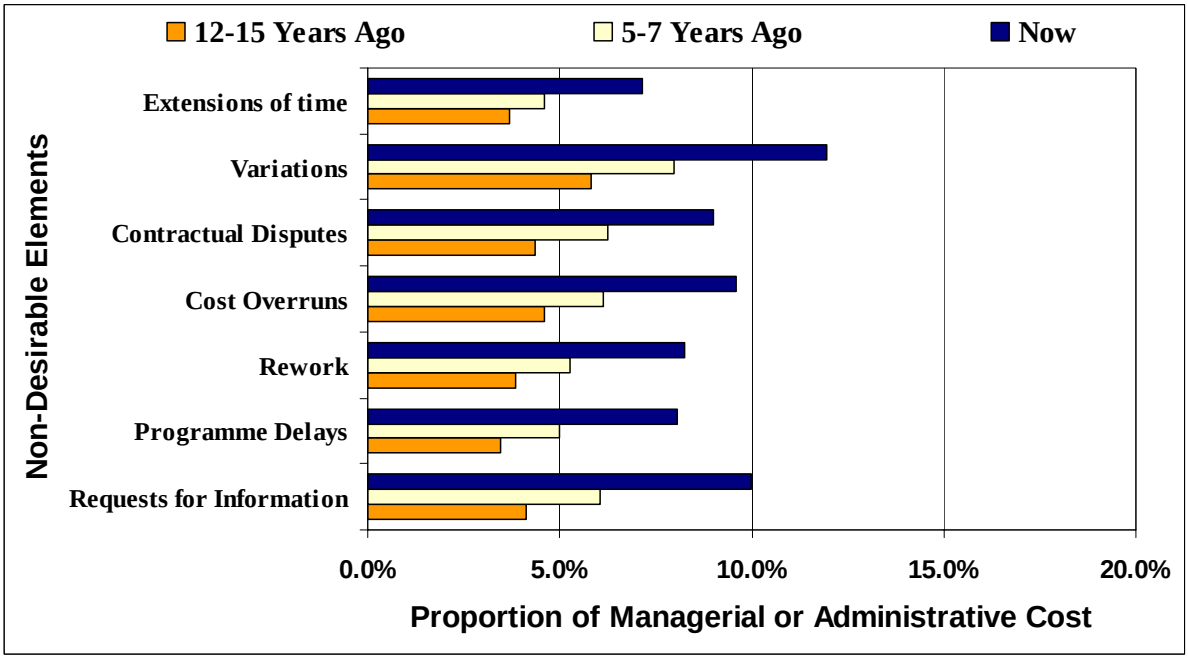


Figure 2.40 Average proportion of managerial or administrative *cost* used in managing non-desirable elements of construction

As can clearly be seen, Figure 2.40 is quite similar to Figure 2.39, in that it shows a dramatic increase in the managerial or administrative *cost* expended in managing the non-desirable elements of construction listed. While the results indicated that *extensions of time* showed the least *cost* increase, the extent of that increase was still 93.0% over the 12 to 15 year time period. As was the case in relation to *time*, *requests for information* have also shown the greatest increase in cost (143.0%), over the time period. Similarly, *variations* now also consume the greatest proportion of managerial or administrative cost, using up an average of 11.9% of the project allowance.

Once again, when all the elements listed are considered together, the results show an overall increase of 114.0% in managerial or administrative cost expended on these elements, from their levels 12 – 15 years ago. From a previous overall average of 29.9%, the proportion of total managerial or administrative cost required to look after these elements, has now increased to a total of 63.9% of the total project allowance.

Looking at the relationship between the proportions of both managerial time and cost allowed, it is clear from Figures 2.37 and 2.38, that the correlation is high. The correlation statistic between both time and cost for each of the specific time periods, came to 0.80, which represents a very strong positive relationship. The correlation statistic between the responses for a specific time period and the responses for the previous time period, is also high for both time and cost issues, with a correlation statistic of approximately 0.75 for each period. This indicates the increases have been consistent for all elements across each time period. All factors and factor interactions were statistically significant for this question. The level of significance varied for the elements and time periods, but again the magnitude of the differences was minor. Australian Capital Territory for both time and cost for each time period was lower than the other states. The other notable factor was E-mail where those with e-mail facilities indicated a higher percentage allowed than those without e-mail facilities did. The magnitude of the difference was only marginal for the factors.

In below a comparison between the total change in managerial or administrative time and cost due to all the non-desirable elements of construction listed, is shown. This chart clearly shows

that the rate of increase over the last period has been significantly greater than it was over the first period, for both issues. Due to the continuing increase in the proportion of managerial or administrative time and cost required to manage these non-desirable elements of construction, it is expected that contractors will need to look seriously at increasing their allowances, to ensure that all the elements are managed effectively. As is to be expected, these additional costs will be passed on to the clients by way of increased tender bids.

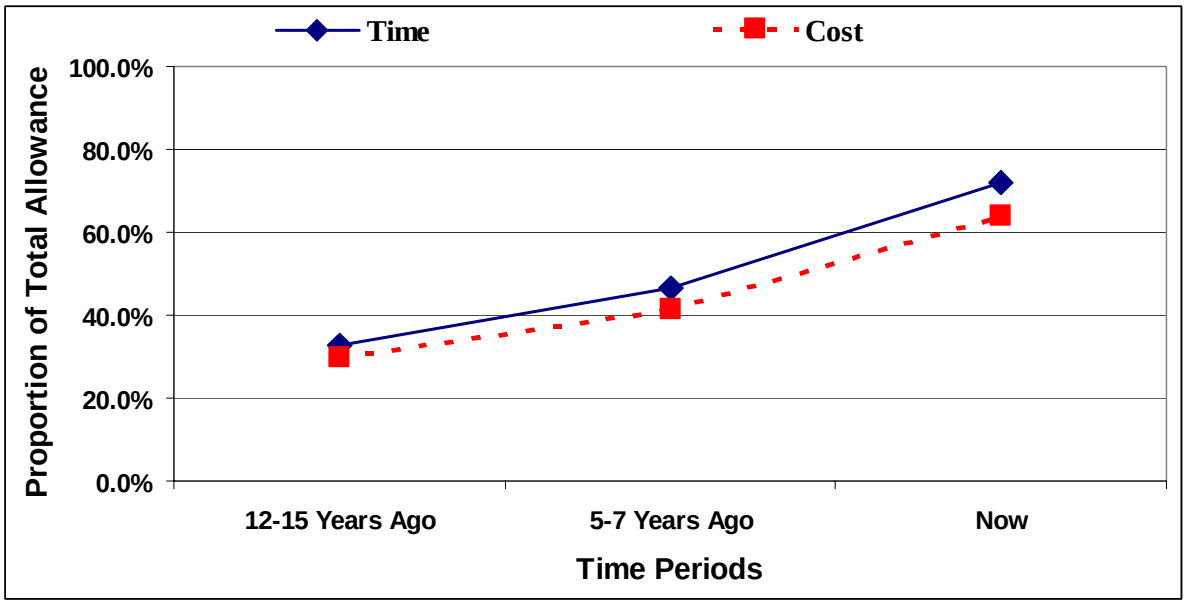


Figure 2.41 Comparison of the changes in the proportion of managerial or administrative *time* and *cost* used in managing non-desirable elements of construction

2.4 Section 4 – Organisational profile and general comments

2.4.1 Section 4 – Overview

The aim of this section was to try to identify any trends within the industry by investigating the organisational profile of the various companies to which the respondents belong, as well as giving the respondents the opportunity to provide general comments relating to the issues raised in the questionnaire as well as the industry in general.

In relation to the organisational profile, the questionnaire looked at such issues as; *years of operation*, *staffing levels*, *company turnover* and *level of Quality Assurance* (QA) accreditation attained by each organisation. In relation to *years of operation*, almost 60% of respondent organisations have been in business in their state for over 15 years, with just 7% having only been in operation for 5 years or less. As for the respondents themselves, nearly 90% have worked in the construction industry for 15 years or more ensuring the validity of the data obtained. Based on *staffing levels*, it can be seen that medium to large size companies figure prominently in the respondent organisations, with 38.1% having between in 16 and 50 employees and a further 31.1% having more than 50 employees.

In looking at *company turnover*, the questionnaire also investigated the proportions shared by the different project delivery methods – *Traditional, Design and Construct* and *Management*. In all 89.0% of respondent companies carry out work under the *traditional* method, 76.5% in *design and construct* and only 58.7% have projects using one of the *management* project delivery methods. The proportion of total turnover attributed to the *traditional* method (44.5%) is significantly greater than that produced under either the *design and construct* (30.5%) or the *management* (25.0%) project delivery methods.

Comparing the various market areas, the *government, heavy industrial* and *commercial* sectors, represent by far the most predominant areas of work, while the *residential* and *recreational* sectors were the least common work areas. The *traditional* method was the dominant project delivery method in all areas excluding *heavy industrial*, where *design and construct* had the highest proportion of turnover.

When asked to consider the level of quality assurance (QA) implemented approximately 63% of contractors either have a fully implemented QA system or are in the process of attaining ISO 9000 accreditation. A further 29.7% utilise an “In House” QA system.

2.4.2 Question 4.1 – How many years has your organisation been in operation in your state?

In Question 4.1, contractors were specifically asked how long the organisations that they worked for had been in operation in their state. In Figure 2.42 below, we can see that 59.9% of respondent organisations have been in business in their state for over 15 years, indicating that the majority of companies have been in operation over the time frame being investigated. This corresponds favourably with the profile of the respondents themselves, of which 89.6% have worked in the construction industry for 15 years or more, further ensuring the validity of the data obtained in relation to the time based questions. Those organisations that have been in operation for just 5 years or less represent only 7.3% of the respondent companies, whilst the proportion of companies that have been in operation for more than 50 years is just slightly higher at 8.5%.

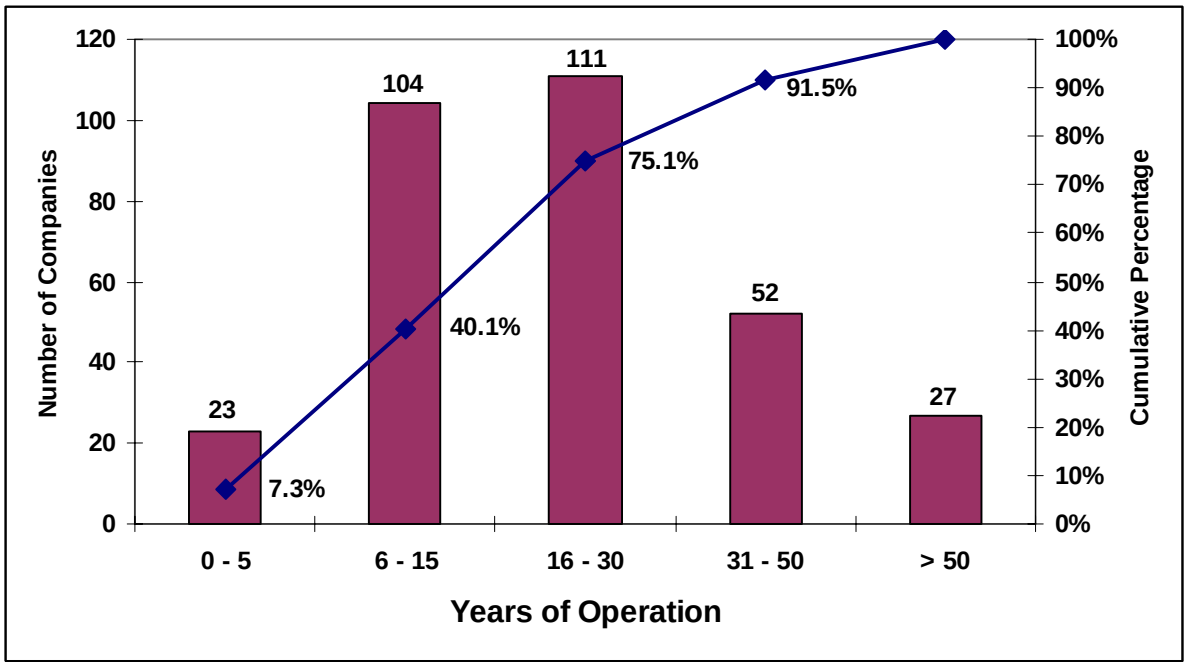


Figure 2.42 Number of years the respondents' organisations have been in operation

2.4.3 Question 4.2 – How many people does your organisation employ in your state?

Having determined the duration of operation of each respondent organisation, Question 4.2 aimed to get an indication of the size of each organisation by specifically asking contractors how many people their organisations employed in their state.

In Figure 2.43, below, we can see that medium to large size companies figure prominently in the respondent organisations, with 38.1% having between in 16 and 50 employees and a further 31.1% having more than 50 employees. Those organisations that have just 5 employees or less represent only 7.6% of all the respondent companies.

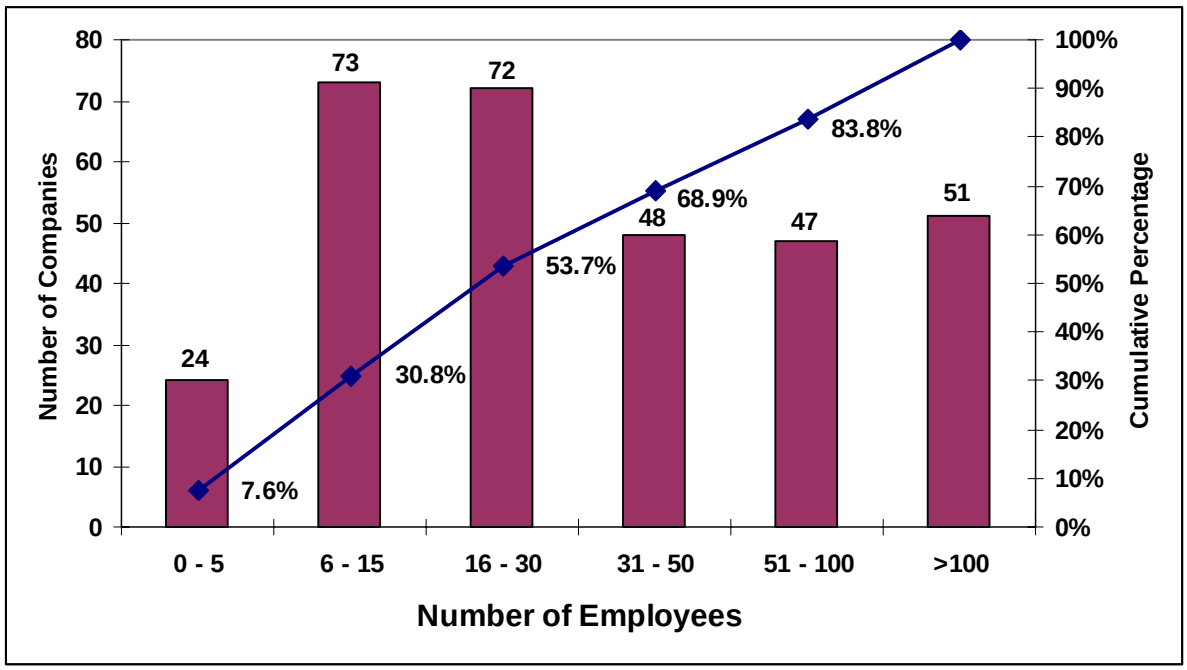


Figure 2.43 Number of people employed by the respondents' organisations

2.4.4 Question 4.3 – Total turnover range for the previous financial year (1997 / 1998) for each of the project delivery systems stated.

In Question 4.3, contractors were asked information relating to the total turnover of their organisation for the previous financial year (1997/1998). In addition to obtaining overall totals, the questionnaire also investigated the proportions shared by the different project delivery methods – *traditional, design and construct* and *management* – by asking the respondents to indicate the amount of total turnover attributable to each method.

In Figure 2.44 below, the chart shows that while the usage of all three delivery methods is fairly similar for projects up to around $5Million, from then on, the *traditional* method is consistently the more preferred procurement method. Further analysis of the responses indicates that while 89.0% of respondent companies carry out work under the *traditional* method, 76.5% are involved with projects procured using *design and construct* and only 58.7% have projects using one of the *management* project delivery methods.

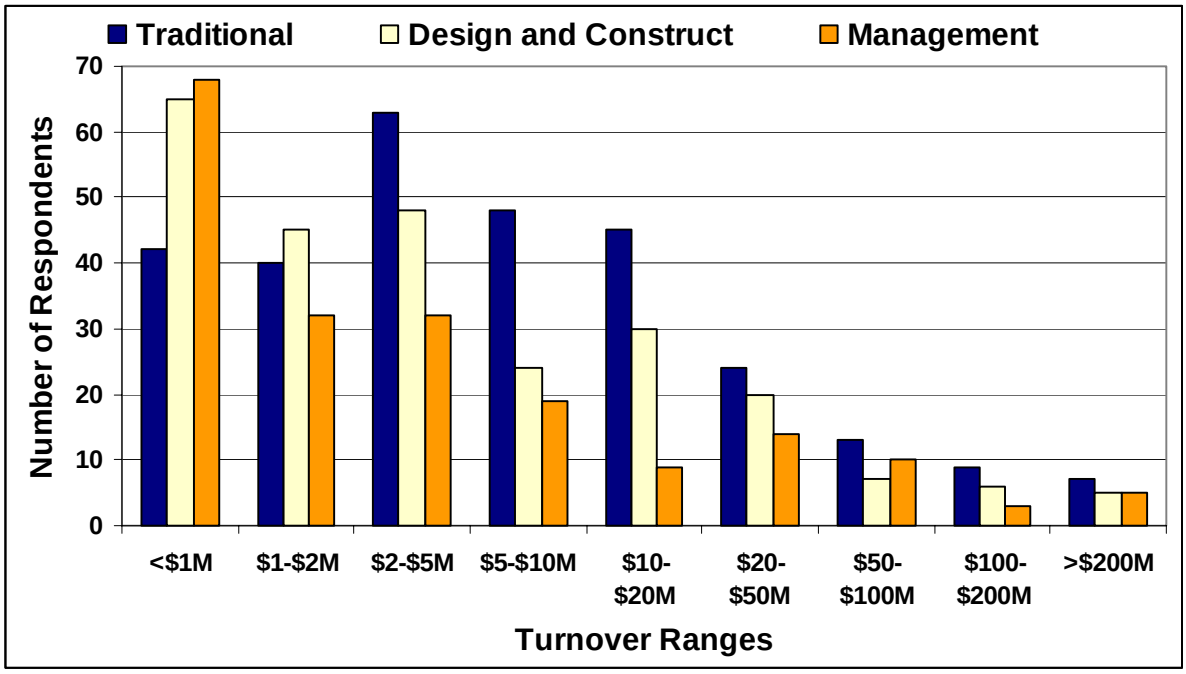


Figure 2.44 Industry turnover by method of procurement

In trying to determine the extent of total turnover attributable to the respondent group for each project delivery method, the principles of the *central limit theorem* have been used to calculate an approximate overall value of work carried out within each turnover range and project delivery method. As can be seen in Figure 2.45, the proportion of total turnover attributed to the *traditional* method (44.5%) is significantly greater than that produced under either the *design and construct* (30.5%) or the *management* (25.0%) project delivery methods.

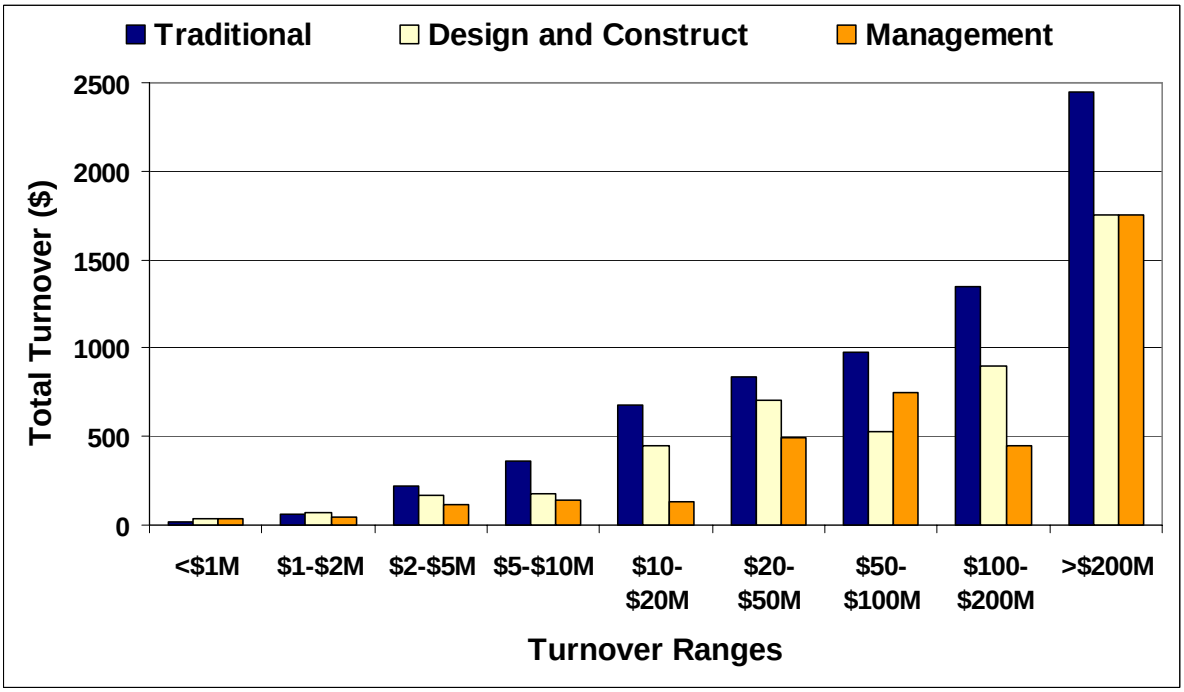


Figure 2.45 Approximate total turnover attributed to each project delivery method within each turnover range

The charts also highlight an interesting situation, in that whilst the number of contractors that operate in the $0 to $20M range may represent 83.2% of all respondents, the turnover attributable to that group is only 17.3% of the total. Or seen another way, for those contractors that have turnovers in excess of $100M, whilst they may only represent 4.8% of all respondents, the turnover attributable to this group calculates out to 55.3% of the total.

2.4.5 Question 4.4 – Proportion of turnover carried out in the market segments listed

To further determine the makeup of the contractor group, Question 4.4 asked the respondents to indicate what proportion of turnover was carried out in each of a number of different market areas, as listed in Table 2.6.

Table 2.6 Market Areas Listed

Market Areas Listed
a) Light industrial buildings
b) Government buildings
c) Commercial buildings
d) Hotels/Resorts
e) Recreational facilities
f) Apartment blocks
g) Residential housing
h) Shopping centres
i) Heavy industrial projects
j) Civil engineering projects
k) Other (specify)

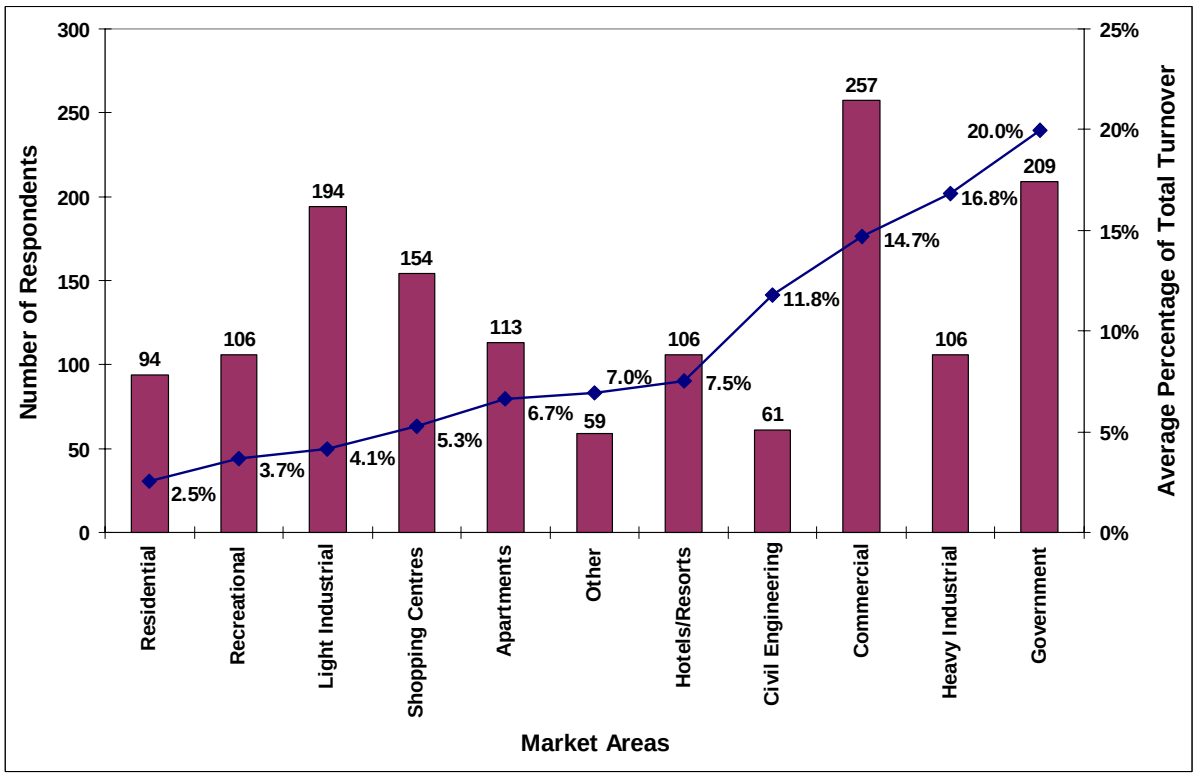


Figure 2.46 Number of contractors working in each market sector and average percentage of total turnover that each sector represents

In Figure 2.46, we can see that overall, the *government*, *heavy industrial* and *commercial* sectors, represent by far the most predominant areas of work and represent a little over half of all respondent turnover. At the other end of the scale, the *residential* and *recreational* sectors were indicated as being the areas in which the respondents were involved the least.

Further analysis was also undertaken to try to determine what proportion was made up by the different project delivery methods within each market area. As can be seen in Figure 2.47, the *traditional* method had the highest proportion of industry turnover within all market sectors, except for the *heavy industrial* sector where *design and construct* had the highest proportion of turnover. These results are based on an average for the responses from the individual contractors and assume that the percentage of work achieved for the particular sector was proportional to the value achieved for each delivery system.

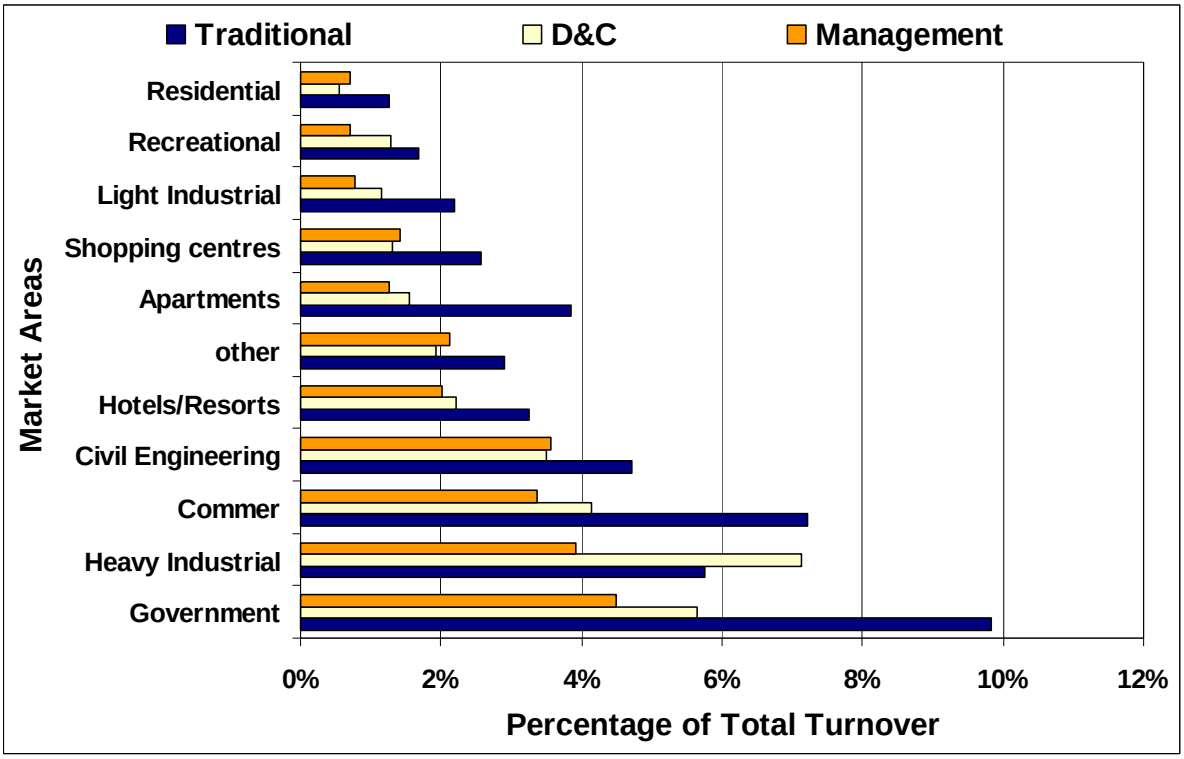


Figure 2.47 Proportion made up by the different project delivery methods within each market area

2.4.6 Question 4.5 – Level of Quality Assurance (QA) accreditation for contracting organisations within the Australian construction industry.

To try to determine the extent to which Australian contractors had embraced Quality Assurance (QA), Question 4.5, asked contractors to indicate what level of QA they had achieved, based on the list of options shown in Table 2.7.

Table 2.7 Levels of QA Accreditation

Levels of QA Accreditation
a) Fully QA accredited to ISO 9000
b) Have obtained *substantial implementation* certification
c) In the process of becoming QA accredited
d) Have own in-house quality system
e) Not started QA accreditation procedures

In Figure 2.48 below, the chart shows that while 40.6% of contractors were fully accredited, a further 22.5% had either achieved *substantial implementation* certification or had started the process of QA accreditation. At 29.7%, it is quite a large proportion of contractors that have decided that it is either better or easier to develop and implement their own in-house quality system than to obtain full ISO 9000 accreditation, while the remaining 7.2% do not appear to have started on any quality system.

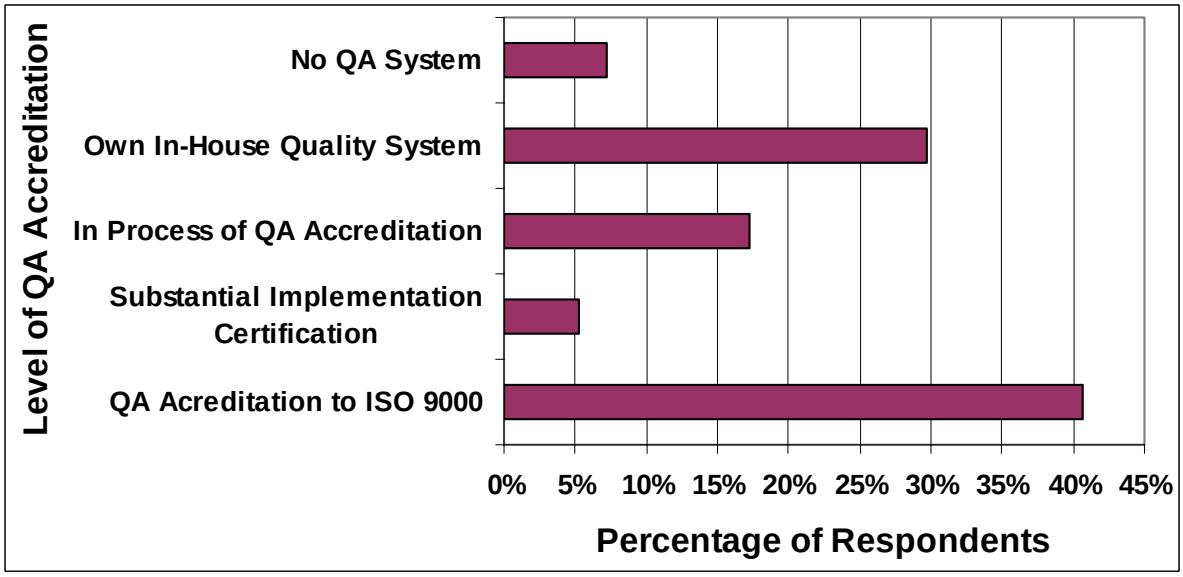


Figure 2.48 Overall level of Quality Assurance (QA) of the respondents

To see if there were any major differences between the different contracting groups, further analysis was carried out. In Figure 2.49 we can see that the head contracting group had a significantly greater proportion of organisations that had achieved full QA accreditation, while the trade contractors had a much greater proportion using their own in-house quality systems. This difference between the two groups may to a large part be due to government project selection criteria in some states requiring head contractors to have a certain level of QA, before those companies can be considered for work.

The figures also showed that those companies that had either their own in-house quality system or did not appear to have started on any quality system, were on average, generally smaller than those companies that were fully accredited.

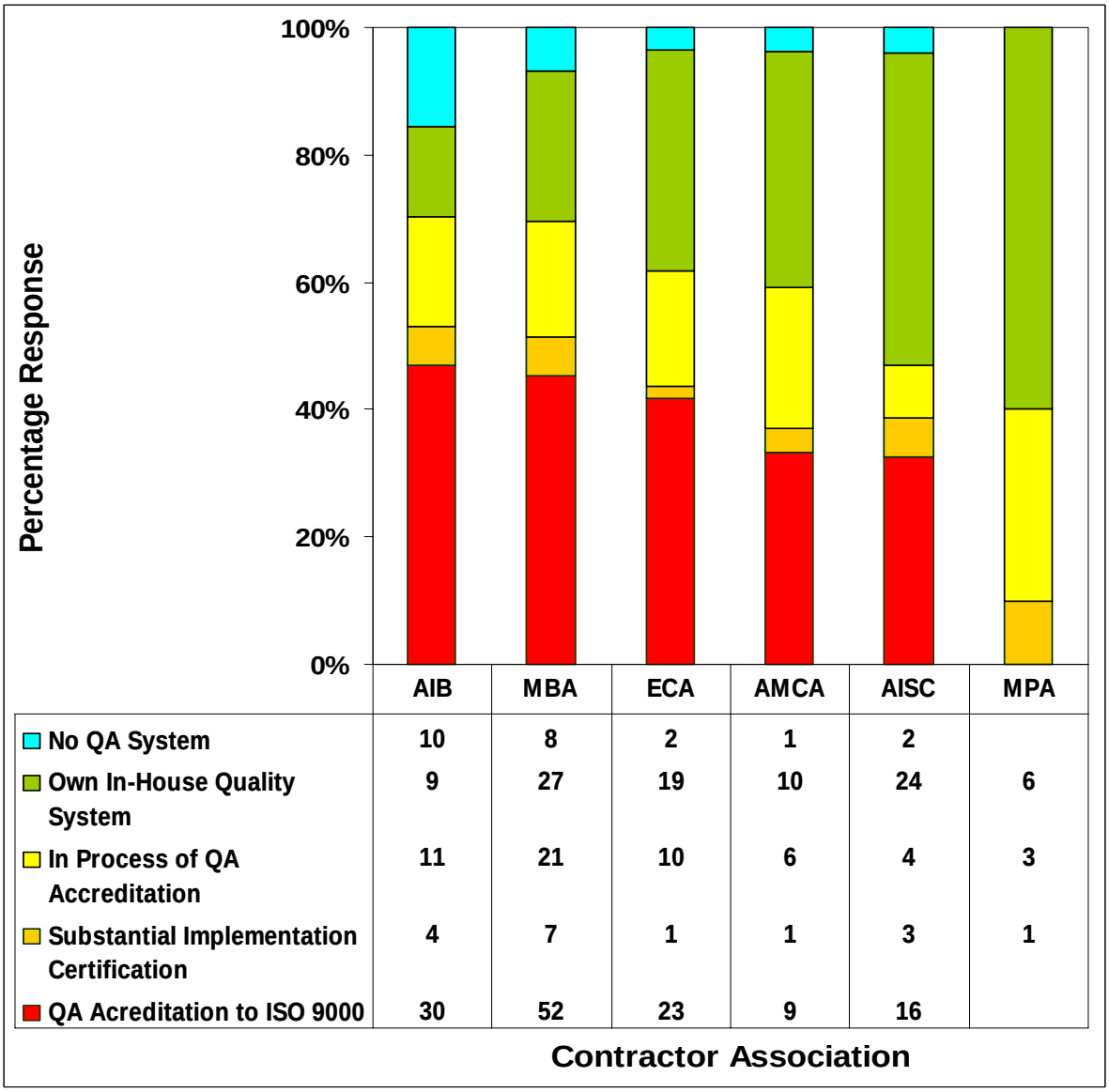


Figure 2.49 Level of quality assurance of the Australian construction industry

2.4.7 Contractors' Comments

In this section of the questionnaire, contractors were given an opportunity to comment on the issues raised within the questionnaire and on any other issues not raised but which they felt should have been, due to their effect on design and documentation quality or construction process efficiency.

In total 153 contractors took the extra time to comment and this represents almost half (46.8%) of all respondents. While some of these respondents only provided a few comments, a large number offered several observations. One respondent was so moved by the issues raised in the questionnaire, that he provided three pages of comments on what he felt was wrong with the industry and how we might go about improving the situation.

To simplify the analysis of the comments, each comment raised was classified into one of a number of categories, from which the information was then tabulated. The results of this analysis can be seen in Figure 2.50.

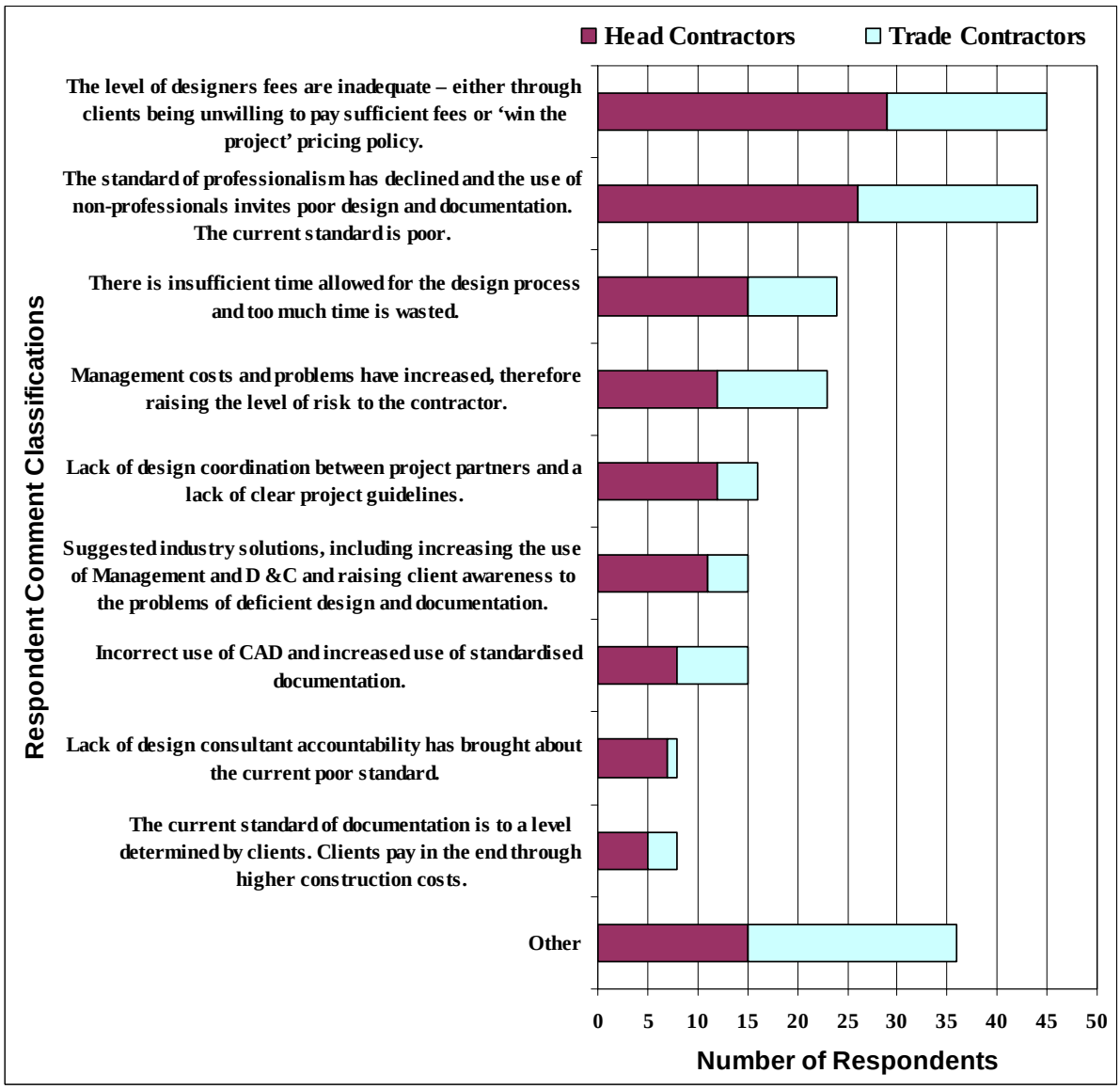


Figure 2.50 Number of comments pertaining to specific issues

In essence, the comments argue that there is a problem with the current standard of design and documentation within the Australian construction industry and that this poor standard is affecting construction process efficiency. Various reasons for the problem are given, however the predominant ones relate to insufficient design fees, a decline in designer professionalism and professional standards and insufficient design time. The collection of comments grouped under *other* included support of issues raised in the survey document, contractors drawing attention to the true cost of deficient design and documentation to the economy and many other diverse statements.

Head contractors make up 60% of the comments in total but proportionally this is in keeping with the response rate. The comments came from all fields and states with no particular group figuring prominently in the comments. The members of the MBA provided most of the suggestions for improving the current standard of design and documentation.

To try to provide a feel for the types of comments given, extracts from some of the respondents' comments are listed below under the major topic areas. Overall, there were many interesting comments provided, either by way of a critique of various aspects of the industry, or as constructive insights into how we may improve the current situation.

Insufficient design fees or designers being selected on the basis of lowest cost

Client reluctance to fund proper preparation of documentation and consultant designer competitive cut pricing of documents with withdrawal of supervision rate is causing the current approach occurring. "Pay peanuts and you get monkeys and we've got a zoo full'

Questionnaire has ignored possible causes for poor design and documentation. These are: - poor selection of consultant; ever declining design fees; low salaries for design staff; quality of design staff; design time allowed. Situation is going to get worse unless these factors are addressed

I think a lot of the problems with design and documentation are related to designers being secured on a cost basis.

The deterioration in design and documentation is a direct result of the squeeze on design firm fees. Design criteria today is more in an implied form, hence contractors are forced to accept more risk. Also the cost squeeze inhibits consultants being able to ensure that clients receive what they pay for. Some would argue that clients deserve cost blowouts due to their reluctance to pay the correct design fee at the beginning.

Design and documentation quality varies greatly per consulting firm. We are getting what the client is willing to pay for.

Other causes of design and documentation deficiency

It's all about money. You get what you pay for. If the client only budgets 2% for design and documentation that's all he gets. The entire industry is dollar driven and with small margins and tough competition everyone is cutting corners just to survive. You can't blame the designers for the current state of our industry, we're all guilty one way or the other.

As a general comment, I would view the decline of documentation standards to align closely with the introduction of CAD & computers (word Processors) into the industry. These were seen as a method of improving efficiencies and delivering cost reductions. The lowering of costs was a justifiable requirement in the interest of delivery of cost efficiency, however with the lowering of fees we have seen a corresponding decline in the quality and efficiency.

The current design and documentation process has created high volumes of "Generic" CAD based information which is often poorly coordinated and generally lacking in overall understanding of the clients goals in commissioning the project. Lack of people contact by designers is an ever-increasing factor.

Our Company specialises in D&C. Technology has allowed advances in delivery & quality of documentation, at the same time designers are not given sufficient time to complete and coordinate documents mainly due to unrealistic time constraints put on them by clients, in many cases caused by their own lack of knowledge or inability to make timely decisions and then expecting the designer & builders to meet unrealistic deadlines. Clients need to become part of the design team to gain better understanding of issues involved.

The main problem in the industry is the continuing trend for designers to take less and less responsibility for full extent of what they should provide as coordinated design and documentation (mainly under pressure of client to minimise design costs) and transfer more design elements such as mech., electrical, fire, hydraulics, etc onto the builder

In my view the decline in quality of design and documentation arises from the clients' lack of understanding of value of high quality design and documentation. This partly arises from there being no industry-recognised methods of measuring the value added by good design and documentation.

The noticeably lower quality of young professional experience / construction knowledge is also a major factor.

There is only one winner – the client

The design process has generally improved with time, however market forces are taking their toll on the score and quality of the documentation that is being produced. Building contractors are being required to interpret documentation and accept some of the risks associated with poor documentation. The result is that contractors need to devote management resources to clarifying ambiguities. Market pressures are such that it makes it increasingly more difficult for contractors and consultants to recover these costs. While consultants and contractors are willing to put up with this treatment, clients will continue to drive costs down, and profit from the situation.

Or, do clients really pay for it all in the end

It would appear the problem with documentation starts with the actual client screwing down the consultants fees trying to save $ but what they need to realise is that all the contractors and sub-contractors have had to add to their overall quotes to cover or at least to try and cover the costs involved with lack of and conflicting information on the consultants documents.

Cost savings in fees is more than offset by increases in administration & project costs.

With reference to fast track projects I believe that if the developer (public or private) allows sufficient time to complete documentation prior to tendering, the end result would be:- More competitive pricing, -A reduction in variations, -A reduction in use of RFI's (a major cost to Eng., Arch., Fabricators etc), -Less extensions of time claims, -A better (both financially and timing) return to developer, engineer, architect, builder, fabricator etc.

There appears to be a common perception from clients that paying less "up front" will reduce the overall cost. This is incorrect as I believe the survey shows that builders administration has increased and inadequate design results in additional variation costs. The true cost of construction will ultimately be realised, and I believe it would be less stressful for all if this work was performed up front.

A popular solution – Design and Construct. Is this the way to go?

Quality of design is largely dependent on the quality of the people within the design team and the amount of the fee. If a relationship (D&C) exists with the team then the quality and quantity of design can be both managed within the fee structure.

Design and construct affords the opportunity to have control over the process but time and cost factors generally prevent the design and documentation from being fully developed hence putting the onus on foreman and project managers to finalise the design as they are building, leading to time and cost inefficiencies.

I have found the quality in design and specifications to be below average to poor quality, I think due to financial restraints put on consultants and feel that we offer a lot more in the field of design and construct and would like to see more projects go this way.

Margins are lower. Architects & consultants fees are lower. Project overall time duration's are less. Quality has suffered. Bills of Quantities are not guaranteed. The contractor is taking more / most of the risk. Bankruptcy & closures are common. Design & construct appears to be the solution.

Other solutions to improve design and documentation quality and industry relationships

Overall the level of design and documentation has been reduced. An architect isn't considered as an important player in construction. The level of design obviously has a bearing on fees and is also the responsibility of the client taking the design serious and paying decent fees.

Inordinate amounts of time and cost are thrown away through unnecessary rectification and/or redesign. I feel higher levels of communication are required and an easier access to information by all design disciplines is needed.

Our industry is entering into a new era where the concept of "partnering" will evolve due to cost / time constraints placed on our designers and consultants.

Accurate design, planning and documentation (particularly Bills of Quantities) along with equitable contracts would save vast amounts of time and money which are currently wasted in the construction industry today and getting considerably worse over time.

3 Conclusions and Recommendations

In the introduction to this report it was stated the purpose of the survey was firstly to determine the extent of change in the quality of design and documentation produced within the Australian construction industry over the past 15 years and then to determine what effect, if any, such changes may have had on construction process efficiency. The questionnaire was specifically designed to obtain this information from the contractors by way of both their perceptions of the changes in design and documentation quality as well as their assessment of the impact that various design and documentation quality levels have on the way they do business.

As was outlined earlier, the respondents were classified into a number of groups based on various factors and the comparisons of the responses for these groups indicate a general level of agreement among those surveyed to the issues raised in the questionnaire. Overall, the number of responses received for the survey has ensured that the results determined are statistically significant and generally representative of the opinions of the contractors' sector of the industry.

Overall, the responses provided indicate that one of the major problems in the Australian construction industry is the continuing decline in the standard of design and documentation; particularly documentation. Contractors have indicated that the standard of design has declined overall and although the combined average level of incorporation for design quality attributes initially indicated a marginal increase over the past 12 – 15 years – from an overall average of 55% incorporation 12 – 15 years ago, to an average of 57% now – further analysis still showed a significant decline. In contrast however, contractors were almost unanimous in their responses indicating a dramatic decline in documentation quality. While the combined average level of incorporation of documentation quality attributes was rated 60%, 12 – 15 years ago, this has since declined to an average of only 38% incorporation, now.

When considering individual attributes, issues such as *proper examination of design proposals* and the *accuracy*, *completeness* and *certainty* of documentation were the areas of main concern. Other issues, such as the *relevancy* and *timeliness* of documents and *coordination between disciplines* were also seen as being major problem areas for the contractors. And according to the results, the overall standards for these issues have been declining for quite some time.

When the effect of different procurement methodologies on design and documentation quality was tested, it was found that the decline in quality of both design and documentation was most evident under the *traditional* project delivery system, where the contractors indicated an overall decline of 28% for design and just over 35% for documentation. While the quality of design and documentation has also declined significantly under both the *design and construct* and *management* project delivery methods, the level of decline has been much less. It is interesting to note that the quality of design and documentation obtained under both *design and construct* and *management*, is now considered to be greater than under the *traditional* method. Considering that 44% of respondent turnover was carried out under the *traditional* project delivery system, this should be of major concern to industry clients. It is also interesting to note that while contractors rated design issues such as *innovation*, *material efficiency* and *economy* as having improved over time, one of the design problems indicated as occurring most frequently, was that the design is not achievable within the project budget.

As to whether the overall quality of design and documentation has been greater on public sector projects than on private sector projects, contractors are divided. In total, 37% of respondents indicated that the quality has been greater on public sector projects than on private sector projects and while 44% indicated the quality has been as good if not greater on private sector projects than on public sector projects, 19% were unsure.

When asked to consider a number of non-desirable elements of construction, contractors indicated that the overall proportion that was directly attributable to design and documentation deficiencies was high, with issues such as RFI's and variations figuring prominently. Not only did these two issues also receive the worst ratings for the overall extent of occurrence at the current time period and increasing the most over time, but they also consumed the highest percentage of managerial cost and time relative to the issues raised. The total amount of managerial time allocated for the non-desirable elements covered in the survey, has increased dramatically over time and now occupies an average of 72% of all managerial time, compared with an average of only 36%, 12 – 15 years ago. An average of 65% of all managerial cost is also spent on these non-desirable elements, compared with an average of just 33%, 12 – 15 years ago.

The occurrence of issues pertaining to design and documentation deficiencies has also increased over time, with the measurable impact being an increase in the overall cost and time for a project. The results of the survey clearly show that project costs increase as the quality of design and documentation provided declines. Based on the current level of incorporation of design and documentation issues and the frequency of occurrence of design and documentation deficiencies, the current standard of design and documentation is generally considered average to poor, although probably closer to poor. Based on this current poor standard of design and documentation quality, contractors have indicated that tender prices being submitted have an average allowance increase of around 7% built-in to try to account for decreased construction process efficiency. The time allowances made for project completion are also similarly affected, based the same perception of the current standard of design and documentation quality.

Through their comments, contractors have indicated that insufficient design fees, a decline in designer professionalism and professional standards and insufficient design time are the main factors influencing the current poor standard of design and documentation quality. Contractors also indicated that there are other industry and social costs that can be attributed to the poor standard of design and documentation, including such things as more frequent litigation and increased worker stress levels, not to mention the consequential flow on costs to the rest of the economy.

The results of the survey show an obvious need for an improvement in the standard of design and documentation produced for construction projects. Based on the responses, the benefits that could be achieved from a better standard of design and documentation would include;

- more projects being completed on time, within budget and with a reduced likelihood of legal action due to contractual disputes;
- less RFIs, variations and rework;
- contractors being able to minimise the management time and cost spent on non-value adding activities.

These benefits would ultimately be reflected in reduced project and contractual risk, reduced project time and cost and a higher level of profitability for clients, their consultants and the contractors.

By selecting design consultants based on low fee levels and minimum service and by reducing project time frames all in an effort to minimise costs, clients and developers were by their own actions, contributing to the problems that lead to inefficiencies in the construction process and increases in overall project costs and durations. The results of this survey clearly shows a need for clients and developers to allocate adequate funds and time to the planning and design phases of a project, in order to maximise construction process efficiency and minimise overall project costs.

Improvements in construction process efficiency will result from creating an awareness of the value of quality design and documentation and the introduction of selection criteria that includes consideration of the designer's skills and experience.

4 References

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5 Appendix

Attached is a copy of the Contractor's Questionnaire – for reference purposes.