CONSTRUCTION TIME PERFORMANCE IN MULTI-UNIT RESIDENTIAL CONSTRUCTION -INSIGHTS INTO THE ROLE OF PROCUREMENT METHODS

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Construction time performance variables have been identified in recent work undertaken for the Construction Industry Institute of Australia (CIIA) which related specifically to non-residential non-engineering construction projects. This work involved face to face questionnaires surveying 45 completed projects. Results indicate project team effectiveness contributed significant influence on construction time performance. Project complexity also contributed to construction time performance. Further studies were undertaken using a similar survey method to bridge the gap of knowledge pertaining to construction time performance and multi-unit residential construction. Results from the CIIA and this study are compared and reported upon in this paper. Conclusions from the latest survey indicate that the following factors also affected construction time performance: relationships between builder and sub-contractor; the degree of experience and expertise in the same type and size of project; the builder's current workload and resource availability; and procurement method. This latter factor is addressed in this paper.

Keywords: Construction time performance; contract variations, procurement; risk.

INTRODUCTION

Construction time performance (CTP) factors have been identified and their impact explained in previous research for non-residential building construction and engineering projects (Walker and Sidwell 1996). There has been very little research, however, in the area of CTP and multi-unit residential construction. Results of recent research (Vines 1997) into CTP for multi-unit residential construction is explained in this paper.

The reason that Walker (1994) did not consider residential construction projects was that during the time frame of his study (1987 to 1991) there were few if any multi-unit residential projects constructed. A large proportion of building activity from 1991 to 1996 in Melbourne, however, has comprised multi-unit residential construction. This may be explained by lifestyle and fashion trends resulting in an increased demand for inner city living.

Multi-unit residential builders are generally more familiar with larger, more complex commercial building construction than residential construction. It was found that not

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only those factors previously identified to affect CTP by Walker and Sidwell (1996), but other factors peculiar to multi-unit residential construction were apparent.

The structure of this paper follows an explanation of the research methodology, analysis of one of the four identified clusters of factors affecting CTP and an explanation of the Vines (1997) findings.

RESEARCH METHODODLOGY

Walker's (1994) research instrument was substantially adopted, however, lessons learned from that study framed changes to suit multi-unit residential projects. The Walker (1994) questionnaire was developed from an extensive literature survey developed from the literature current as at 1993. The amended survey (Vines 1997) was formulated from an extended literature survey covering published works from 1993 to 1996 and this helped identify other possible explanations of factors affecting CTP.

Data was sought from a survey of30 completed multi-unit residential projects in the scope range AUS$0.69 to AUS$26.56 million dollars (indexed to January 1990 using the AIQS construction inflation index). Construction costs were taken from the mid-point of the construction process. Projects selected for investigation were carried out between March 1991 and June 1996, and this represented 22% of multi-unit residential projects constructed in the Melbourne metropolitan area. Respondents to the survey were drawn from senior construction management team representatives. Generally managers of the construction management team were selected as they were considered the most qualified person to judge the impact of actions, attitudes and relationships of other teams involved in their project. This person, working at the 'coal-face' of the project, had to cope with the complexity of the project in realising its built form.

The questionnaire amended from the Walker (1994) research instrument included 93 questions eliciting both objective and subjective data. Objective data gathered included such items as construction duration, extensions of time granted measured in working days, and final construction costs. Subjective data comprised survey respondent's perceptions gathered from various questions posed. A seven point scale ranging from 'very low' to 'very high' was used to record responses to questions posed using a structured questionnaire. A typical example of a 'subjective' data question asked in the survey is 'Rate the response that best describes your opinion of the following client's representative sophistication measures *ability to contribute ideas to the design process.'* The respondent provided an assessment based upon 1 = very low to 7 = very high.

These objective and subjective data results were then analysed using the statistical technique analysis of variance (ANDY A) to establish which factors directly affect CTP. The method of analysis followed the Walker (1994) approach. This is explained in detail elsewhere (Walker 1997a; Walker and Sidwell 1996). Results of statistical tests were obtained at the 95% level of significance, this means that 5 occurrences out of 100 could be obtained by chance. This level of significance was considered acceptable in the Walker (1994) study.

Most respondents provided two case studies. This proved invaluable in generating discussion about the respondent's theory of which factors may affect CTP. In these discussions comparisons were made between past and current projects and the respondents were encouraged through reflection to provide valuable insights into why

some buildings are more quickly constructed than others. Thus, the researcher was able to extract valuable expert opinion freely provided by respondents.

It was also found that in the majority of surveys, a slight tension or reserve initially prevailed, however, by the end of the interview it was difficult to actually conclude the interview as the respondents wanted *to* keep on talking about their 'pet' project.

A discussion of one of the four main clusters of factors found to affect CTP derived from the literature follows together with analysis of survey results and respondent expert opinion.

CONTRACTUAL ARRANGEMENTS (PROCUREMENT METHODS) AND THEIR CONSEQUENCES UPON CTP

Contractual arrangements and relationships with reference to CTP have been explored by many researchers. Barnes and Partners (1984) argue that different contractual arrangements do not affect CTP. However, others (Ward et al 1991; Smith and Wilkins 1996; Walker 1997b) disagree. Those supporting adoption of non-traditional procurement versus traditional procurement emphasise advantages of the construction team's input at the design stage. This input includes: providing advise on buildability; greater cooperation between design and construction teams; and more clearly defined responsibilities of all teams towards achieving project objectives. Sidwell and Francis (1996) argue that early input of the construction and design team results in cost rather than time benefits. Sidwell and Mehrtnes (1996) identified constructability as an approach for prompting potential cost and time savings.

In the Vines (1997) survey, however, contract type did not generally appeared to ~ J significantly influenced CTP. The only project using a combined project management and '! construction management (CM-PM) contractual arrangements experienced a 29% increase ! in mean CTP value relative to the non-CM-PM projects (see Table I Factor ql. 7). .l Interestingly, Twenty of thirty projects surveyed using traditional procurement methods j had a CTP index which was less than 1.00 (where the mean CTP value of the entire) sample's CTP would be 1.00).

General discussions with respondents revealed that a well defined dispute resolution mechanisms assisted good between-team working relationships. These mechanisms clearly J specified how disputes could be resolved when such disputes arose. Not all problems are foreseen. To successfully resolve disputes, mechanisms that clearly define each team's roles and responsibilities in addressing unresolved issues are needed. The contract must clearly and fairly state how this is to be achieved. An open line of communication is extremely important no matter what the circumstances surrounding the issue under scrutiny. The CIIA report research findings that indicate unstructured communication lines are vital for effective CTP (Walker and Sidwell 1996). Results presented in Table 1 (see q16.2.3, q16.2.2, q16.3.1, and q16.3.2) demonstrates and reinforce the belief that sound communications do play an important role in CTP.

Factor	Group 1 CTP	Group 1 cases	Group 2 CTP	Group 2 cases	Trigger	% Diff G1/G2	P-Value
1.15 determining the original completion time	1.08608	9	0.972	21	=1	12	0.0249
1.7 contract type	1.29451	1	0.997	29	=2*	29	0.0209
2.3.2 cr's experience with the building process	1.07046	11	0.970	19	<=5	10	0.0373
2.3.6 cm's experience in this type of building	1.17544	2	0.994	28	=6	18	0.0546
2.4.2 client's time minimisation objective	1.0415	23	0.892	7	>=6	15	0.0051
2.6.2 cr's ability to make authoritative decisions	1.07007	13	0.958	17	=5,6	12	0.0159
2.7.1 design team's confidence in the cr contribution	1.08423	9	0.973	21	=3,4,5	11	0.0288
2.7.5 cr's ability to mould shared project goals and aspirations	0.93345	10	1.043	20	=7	11	0.0261
2.7.9 working relationships	1.04611	18	0.946	10	<=2	10	0.0539
4.1 design buildability complexity	1.09931	11	0.953	19	=4,5	15	0.0015
9.1 economic environmental complexity	1.13973	4	0.986	26	<5	16	0.0244
13.1 cm management systems and procedures	0.95857	15	1.054	15	=7	10	0.0403
14.3 cr's organisational structure to manage risk	1.20075	3	0.985	27	>=5	22	0.0041
15.2 design team's mechanistic - oriented management style	1.0636	12	0.968	18	>6	10	0.0468
15.3 design team's people - oriented management style	1.08019	10	0.970	20	=4.5,5,5 .5	11	0.0248
16.2.3 cm & design team communication for decision making	1.01967	28	0.823	2	>3	20	0.0351
16.2.2 cr & design team communication decision making effectiveness	1.07163	11	0.969	19	=5,6	10	0.0337
16.3.1 decision making communication within the cr team	0.96192	17	1.065	13	=7	10	0.0283
16.3.2 decision making communication within the design team	1.05611	14	0.963	16	=4,5,6	10	0.0479
18.01 number of projects at the same time	1.18252	2	0.994	28	>=5	19	0.0446

2 = Combined Construction Management and Project Management procurement method

Table 1 -Factors Significantly Affecting CTP.

Figure 1 illustrates how inclusion of conflict arrangements may affect CTP.

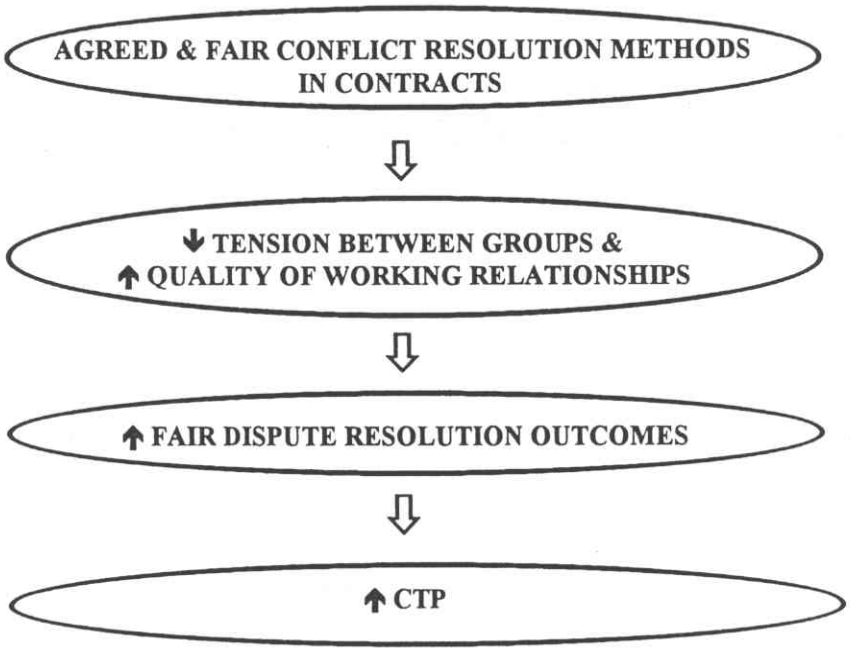

Figure 1 -Team Conflict Resolution and CTP

One respondent reported that one of the main reasons for their project's overrun2 was lack of construction team's advice be taken at the design stage. The CM team was not appointed until the design process was approximately 95% completed. Problems associated with design information also complicated matters in this case. The architectural I practice initially appointed by the client hired a team of specialist designers (services, structural design etc). The architectural firm was subsequently dismissed and failed to fully pay the specialist design teams for their work. When the construction management (CM) ! team was appointed they found difficulty in obtaining architectural design information. This made it complicated for the CM team to operate effectively when they began their role.

The Vines (1997) study also revealed that some construction companies entered into contracts (generally traditional procurement method) accepting non-identified design issue liabilities which were not covered adequately in the plans or specifications. For example, one construction company was provided with a survey indicating the extent of asbestos to be removed on the project but the survey was 4 years old and incomplete. The contractor was expected to remove all asbestos, whether or not it was included in the asbestos survey. Why a company would take on such a liability, if there was a strong possibility that large unforseen cost and lost time losses associated with such liabilities could not be

[2] The final completion time being greater than the original tender time plus approved extensions of time

claimed for, poses interesting questions about the motivation of some contractors taking on projects. A plausible explanation was put forward by one of the respondents stating that at the time of signing their contract with the client there was little other construction work available. Also, if construction management advise on risk sharing was sought at the early stage of project scope definition, subsequent problems associated with contract variations may have been avoided. Figure 2 illustrates how an increase in non-paid variation work due to unreasonable risk sharing arrangements may lead to decreased CTP.

Figure 2 -Relationship between Risk Allocation, Variations and CTP

Continued sound working relationships between all parties throughout the project were found to have a positive influence upon CTP. Evidence showed 18 of the 30 respondents experiencing 'deteriorating' or 'neutral' quality of team working relationships, performed better in terms of CTP than those experiencing better than 'neutral' team relationships.

An explanation offered by one the respondents was that pressure applied towards the end of the project by the client's representative (CR) to simply finish the project, regardless of compensation for cost or time extensions, could result in timely project completion. Intimidation and fear of loosing the opportunity to win future work with a client also plays a strong role in deciding the construction team's working attitude and actions during uncertain or weak economic times. In at least one case, CR pressure of this nature caused friction and argument between team members over interpreting the scope of work.

However, the effect of this pressure prevailed in achieving the project completion within the original time specified. Clarity of understanding scope and complexity by the contractor could also have resulted in avoiding such situations from occurring, ending with a possibly better CTP result. This clarity can be achieved through better design documentation and/or improved definition of risk in contract documents.

The client's time minimisation objective and setting of original completion time proved to be influential with respect to better CTP (see ql.15 & q2.4.2 in Table 1). Results indicate that a 'high' to 'very high' time minimisation objective is associated with a 15% better mean CTP than a 'less than high' value. However, a cost minimisation objective is associated with no significant impact upon CTP. One would have expected that both these factors would affect CTP as construction time is significantly influenced by project scope and scope is strongly associated with construction cost.

The construction team's knowledge about building systems (as distinct from experience in the construction industry) and knowledge of building regulations was found to affect CTP. Linked but separate to risk issues is the appropriate use of specialist advice. It was evident from a number of cases reported by Vines (1997) that greater reliance of performance specifications by trade specialists resulted in better CTP. This may be due to fewer contract variations being generated. Four companies covering seven projects advised that they had in place contracts that made use of the

knowledge and expertise of specialist contractors and specialist consultants by passing on more risk liability to where it could be better managed. This has a two fold affect. First, it limits the likelihood of variation work being generated that is not reclaimable from the owner[3]. Second, unspecified but necessary works would be included and scheduled for by the trade specialist.

Figure 3 illustrates the relationship between specialist trade knowledge and consequential impact upon contract variations generated, and how this in turn affects CTP.

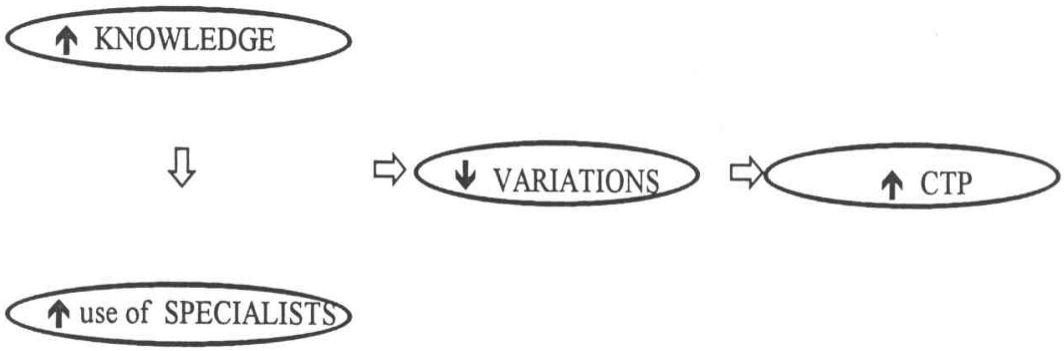

Figure 3 -Relationship Between Specialist Trade Knowledge and CTP

Respondents from the Vines (1997) survey indicated that they were forced on traditional ! procurement contracts to accept the client's view of a 'reasonable' construction period ' rather than their own assessment. Unrealistic completion times may result from inclusion of abnormally high resource allocation and/or overtime worked. Thomas and Arnold :' (1996) concluded that as more craftsmen are hired, a loss of efficiency could be expected. This is often referred to as 'the law of diminishing returns'. Overmanning on site or increasing overtime does not necessarily produce an commensurate increase in productivity, many cases actually show large reductions in productivity due to confusion and poor coordination.

The construction company's current work load was seen as a factor also affecting CTP.

This could be explained in terms of availability of high quality management personnel with good decision making capacity. Companies with a larger number of concurrent projects under way may have a larger pool of available expertise to draw upon. In times of economic recession, some construction companies still tend to maintain their' good' staff and try to find ways of keeping them gainfully active for the company. Thus remaining projects will have higher quality management available on site than in 'good' economic times when management resources may be stretched too thinly.

[3] This can be done by stating that anything not covered by original documentation is required to comply C with current regulations and codes. Any additional or unforeseen expenses are to be born by the specialists contractors as they should be more familiar with risk associated with the work. Provision of safety requirements such as handrails are a case in point.)

Unrealistically optimistic time objectives can also exacerbate builder's CTP problems. Diakwa and Cui pin (1990), in an opinion-based survey of architects, found that CTP is affected by clients generating excessively optimistic and unrealistic contract duration terms imposed by **public** sector clients. Whilst their research results were inconclusive, their question 'number of projects on at the same time' did show a negative impact upon CTP. This finding is contrary to the Vines (1997) survey results of private sector clients which indicated two cases where builders concurrently engaged upon five or more projects achieved significantly better CTP that those concurrently engaged upon less than five projects (see question 18.01 -Table 1). Comments from respondents from both these projects advised that in some previous projects they had experienced a top-heavy management structure leading to the involvement of too many people for making effective decisions. This raises two interesting issues often thought of as public/private sector issues but are better considered in terms of appropriate management structure. One issue is the impact of organisational structure for effective decision making upon CTP. A second issue is the client's time minimisation objectives and its impact upon CTP and how these objectives influence resource demand. It is beyond the scope of this paper to address these issues. Fur further information about this, see Vines (1997).

CONCLUSIONS

Vines (1997) did not provide strong direct evidence that procurement method significantly affects CTP. Interesting issues were raised revolving around project team relationships and risk sharing. Early input by specialist contractors and the construction management team to provide much needed buildability advice was identified as needing to be addressed. Agreed and fair risk sharing formulae and conflict resolution methods must be established to decrease tensions, increase the quality of working relationships and to increase the possibility of win-win outcomes to disputes. It is argued in this paper that these features affect CTP and that the procurement method and contractual arrangements do not directly affect CTP per se.

While the Vines (1997) study was confined to multi-unit residential construction projects, many of the conclusions regarding CTP is shared with the work reported by CIIA (Walker and Sidwell 1996). Anecdotal evidence gathered in the Vines (1997) study not presented here, supports the view that construction expertise is best fully accessed at the design stage of projects. Traditional procurement methods have a poor record of gaining access to this knowledge.

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