CREATING GREATER PROJECT VALUE THROUGH CONSTRUCTABILITY

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ABSTRACT

Traditional project delivery philosophies involve the separation of planning, design and construction functions; this is equivalent to designing a product without thinking about how to produce it. Integration of design and construction is a major opportunity to improve total project performance – to begin with the end in mind.

Constructability is not the review of completed drawings. It is not a criticism of design. Nor is it the optimisation of construction operations at the expense of other project functions. Constructability means thinking about how to build a project before it is designed. It is the integration of construction and start up expertise into all phases of the project.

Integrating construction resources into engineering design has been identified as a key factor in achieving reductions in the capital cost of new facilities. The benefits of constructability are cost and schedule improvement by:

- Optimising the design and construction relationship.
- Optimising details and sequence to meet construction needs.
- Dev eloping simplifying methods.
- Minimising labour intensive designs.

Major cost savings and programme improvements can result from effectiv e implementation of constructability. This paper presents guidelines for effectiv e constructability and provides examples where constructability has enhanced project outcomes.

KEYWORDS

Early Contractor Involvement, Constructability, Project Delivery

1 INTRODUCTION

There are a multitude of procurement options available for capital works. It is clear, however, based on overseas research (Latham and Egan) and experience in New Zealand and Australia that some of the current procurement practices are not providing budget surety or true value for money.

For example we are aware from client feedback that the Engineers estimate is rarely within 20% of contract value. We would also estimate that almost 85% of contracts exceed the tender price and 65% exceed time estimates. Most if not all of this time/scope creep is due to inadequate or unclear design at the time of tender and unreasonable risk allocation.

Often tender documents include clauses where contractors are required to accept weather risk for which no extensions of time can be claimed. This risk is then added to the tender price and the client will be paying for wet weather delays or delay damages – even if they do not occur. Another factor reducing value for money is that innovations that the contractor brings to the contract are deemed to be non-conforming and that the contractor assumes the design risk. This is a significant disincentive to innovation in contracts and significant potential savings are lost to the client.

A number of clients have attempted to gain input from contractors at tender stage by a method known as interactive tendering. This has some merit and can lead to clarification of contractual terms. However, contractors are in a commercial/competitive situation and are aware that innovations divulged may well benefit their competitors.

Similarly value engineering (cost reduction exercises) in the early stages of (traditional) construction contracts has been used to reduce project costs. This almost always results in disappointment as benefits gained from improved construction techniques and innovative solutions generated at this stage of the project, are generally less than the cost associated with re-design and delay to the construction programme.

To achieve the objectives of minimizing risk, maximizing safety, providing budget and programme surety requires a different approach. Integration of design and construction is a major opportunity to improve total project performance – to begin with the end in mind.

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2 PHILOSOPHY OF CONSTRUCTIBILITY

Constructability aims to maximize the benefit to the client by impacting the total project starting in the early planning and design phases when industry knowledge and experience can be used to make better design decisions.

- Constructability is the optimum use of construction knowledge and experience in planning design, procurement and field operations to achieve overall project objectives.

- Maximum benefits occur when people with construction knowledge and experience become involved at the very beginning of a project. The following figure illustrates this.

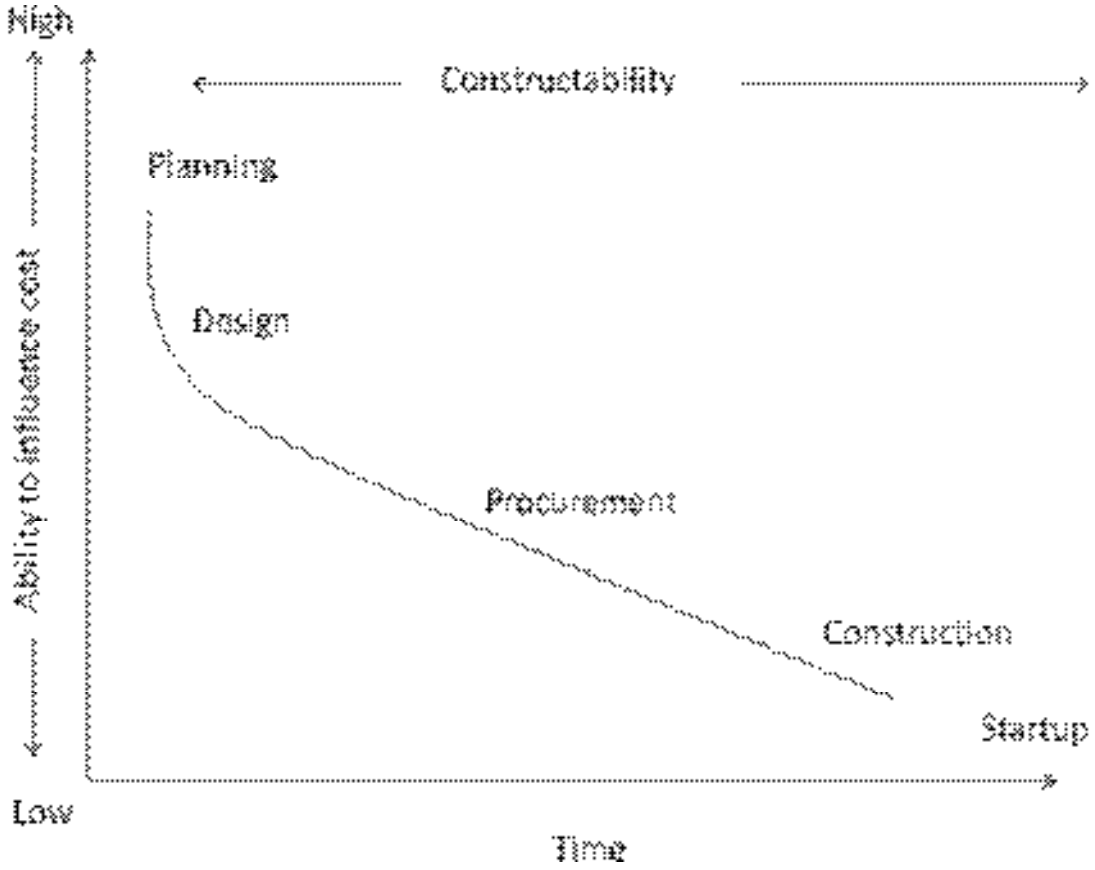

Figure 1: Project Cost reduction Opportunity (traditional procurement)

- Only through the effective and timely integration of construction input into planning, design, procurement and field installation will the potential benefits of constructability be achieved.

- Common industry practice tends to separate the individual functions involved in capital projects by fine-tuning the each individual function to minimize its costs. However, fine tuning the individual functions does not yield the most cost effective project. Constructability integrates these functions, and by so doing, is a powerful tool that can be used on projects

- Traditional separation of engineering and construction early in the project must be bridged if constructability is to work. This bridging requires merging engineering and construction cultures, which have both likeness and distinct differences. This merger must become automatic and permanent at all levels during the project.

- Continuous commitment is important. Front end constructability participants are most effective when they know they are the ones who will have to make it happen in the field. This focuses attention and builds true commitment for constructability within the team.

- The size of a project is no barrier to constructability. It is equally valuable to both large and small projects.

- Long term or complex bureaucracies are not required to make constructability work. Constructability works best when it is an accepted way of doing business.

When constructability is approached solely on a review basis, it inevitably becomes inefficient and ineffective. Designers may become defensive due to pride of ownership and the construction reviewer is reluctant to comment due to lack of engineering expertise or fear of appearing overly critical. Any change at that point represents design rework with additional expense and lost time. Perhaps equally damaging is the loss of face in the perception of the designer that professional judgement is being publicly questioned. The separation of design and construction widens in such an environment, and it has been known to deteriorate into an adversarial relationship. This is obviously not in the best interest of the project and frustrates the very purpose of constructability.

The most effective approach puts the entire constructability team into active roles in an integrated planning and design development process. In that environment, alternatives are discussed up-front and jointly evaluated. One excellent technique is to convene a series of brainstorming sessions. Novel ideas flow most easily at this point , when the project has not been constrained by tight definition and the participants are not concerned with filtering their expressions. If experienced people participate, the value of such sessions can be excellent. Analysis and trade offs are made before the design is accomplished. Design rework is minimized, and the overall design quality is enhanced.

Figure 2: Precast Panel Installation

3 BARRIERS TO CONSTRUCTABILITY

A barrier to constructability is any significant inhibitor that prevents the effective implementation of the constructability programme. Barriers need to be identified and removed for successful implementation. The following table presents some common barriers, shows where they occur and lists symptoms that indicate the barrier is present. Constructability barriers are evident in all organizations, at all levels, within both corporate and project organizations. Four different types of barriers are noted: cultural, procedural, awareness and incentive.

Table 1: Descriptors of Common Barriers to Constructability

Item	***Barrier***	***Symptoms***
1	*Complacency with status quo*	• *Oversatisfaction with performance* • *lack of interest in new approaches, new ideas,* • *no time for strategic thinking*
2	*Reluctance to invest additional money and effort in early project stages*	• *Primary focus on short term profitability,* • *highly constrained funding procedures*
3	*Limitations of lump sum competitive contracting*	• *Reliance on lump sum methods,* • *reluctance to investigate/allow other strategies,* • *highly restrictive contracting procedures*
4	*Lack of construction experience in design organization*	• *Construction knowledge not considered valuable for design professionals,* • *Few opportunities for site visits by design personnel.*
5	*Designers perception that we do it*	• *Design review procedures considered adequate for constructability*
6	*Lack of mutual respect between designers and constructors*	• *Adversarial clannish relationships between personnel*
7	*Misdirected design objectives and designer performance measures*	• *Promotion of goals to minimize design costs at project expense*
8	*Construction input is requested too late to be of value*	• *No construction involvement or understanding of such need in early project stages,* • *focus on construction review of completed drawings.*
9	*Poor communication skills of constructors*	• *Failure to present ideas in a usable non adversarial fashion*
10	*Poor timeliness of constructor input*	• *Lack of pro-active effort, focus on construction review of completed drawings*

Once barriers are identified, they may be mitigated or overcome with specific tactics. Barrier breakers have been evaluated for some of the most common barriers. The following table shows the breakers recommended, including some tactics for each barrier.

Table 2: Constructability Barrier Breakers

Item	*Barrier*	*Symptoms*
1	*Complacency with status quo*	• *Designate a song program champion*
2	*Reluctance to invest additional money and effort in early project stages*	• *Promote the attitude that constructability should be viewed as an investment opportunity with a return.* • *Include constructability as part of a standard bid response*
3	*Limitations of lump sum competitive contracting*	• *Owner/designer acquire in house construction expertise for input during design* • *Select on attributes and negotiate with preferred constructor*
4	*Lack of construction experience in design organization*	• *Communicate construction issues from field to design office* • *Close project loop by getting feedback from the field and by tracking lessons learned*
5	*Lack of mutual respect between design and constructors*	• *Promote teamwork among personnel* • *Establish constructor presence in design process before pride of authorship develops*
6	*Construction input requested too late to be of value*	• *Increase awareness of the necessity for early construction involvement*

4 CONSTRUCTABILITY IMPLEMENTATION

To implement constructability requires a break from traditional contractual practices which only involve the contractor at tender stage. Note that when the scope is clear and the design well defined and detailed this type of contracting can work extremely well. However, with procurement approaches focused also on minimizing consultant costs the level of definition and detail in drawings and schedules is often less than optimal.

Three concepts dominate the non traditional approach to project delivery, coming under the banner of relationship contracting:

Alliancing

Early Contractor Involvement

Build Own Operate (BOOT)

Relationship contracting is not a wooly hand holding exercise. It is a business relationship that is designed to deliver the optimum commercial benefits to all parties involved, including key members of the supply chain.

4.1 ALLIANCE CONTRACTING

The idea is that the Alliance principles support and drive the actions of the parties during the project. Alliance principles include such concepts as:

- Decisions made on the basis of best for project
- Responsibilities clearly defined
- Innovation is encouraged
- The parties need to provide reasonable access to resources (people, materials)
- All communications to be open and based on a relationship of trust and honesty

4.1.1 CONTRACTS BEST SUITED TO ALLIANCING

Alliance contracting is best suited to large and complex projects or programmes where:

- The scope of the tasks to be undertaken can not always be defined in specific detail
- There is a need for innovation and step change development in elements like technologies, methodologies and processes, and
- The projects budget may require change over a period of time and it would be uneconomic to rely on a fixed price lump sum spread out over the term of the contract that prices in a large number of contingencies.

4.1.2 KEY FEATURES

The key features of most alliance contracts are:

- Need to be of sufficient scale and complexity
- Key performance parameters to measure contractor's performance
- A cost re-imbursable approach, backed by open book auditing of all costs, overheads and margin

- Comprehensive dispute resolution provisions which have very limited recourse to the courts and termination ability.

5 EARLY CONTRACTOR INVOLVEMENT

5.1 TWO STAGE APPROACH

A key concern for local government, when considering the use of Alliances is the large amount of management resource required. Succesful alliances require the client to be involved in the Alliance leadership teams and management teams throughout the life of the alliance.

Early contractor involvement is a reaction to the need for the client to place resource in Alliance teams as well as to better understand and equitably allocate risks during construction. A two stage approach to project delivery offers substantial benefits when compared to other procurement options for the following reasons.

The key difference between a pure alliance and the ECI approach is that the alliance brings together a number of parties, including the client, on an equal basis, whereas the ECI approach still gives the client a single point of contact. This is often the most appropriate approach for the type of infrastructure schemes procured in New Zealand.

During the first phase contractors are provided with ample time and resources to design and document the project and identify project risks. This process results in more robust identification of risk and a realistic project schedule and price to be defined. If done in an open book collaborative manner this allows both the client and contractor to understand the risks each party is accepting.

During stage 1the contractor will provide key project management, construction and cost estimating resource and their designer (normally under a sub contract arrangement) will take a lead role in developing the design. The client's advisor can provide the function of peer review.

During the stage 2, construction can commence with negotiated risks. This allows for the establishment of a guaranteed maximum price for the project. This avoids variations and excessive project contingency fees that are normally associated with alternative procurement options.

Alternatives to this approach generally involve the production of a Target Price in stage 2, where both the contractor and client share in any savings or overspend. It is important to note that the success of this type of contracting is dictated by the calibre of the team and their determination to work together in a best for project approach. There will be occasions when individuals from within the project team (client, contractor, designer) will not be suited to this environment.

5.2 SELECTING A CONTRACTOR BY VALUE

One of the key challenges that face clients when considering a 2 stage ECI approach when the lead ECI contractor is chosen on his ability to do the job is how to ensure price tension. The contractor choice could be based solely on attributes including:

Financial standing

- Balance sheet strength
- Profit and loss over previous years
- Insurances

Technical and organizational ability

- Personnel
- Health Safety and Environmental record
- Relevant track record
- QA systems

Some clients choose to engage two contractors at stage 1. This has the advantage of keeping the process of selection to stage 2 competitive. It has the disadvantage that the client contractor relationship that would develop through stage 1 will suffer and it is more expensive for the client and contractors.

5.2.1 BUILDING IN PRICE TENSION

In addition to attributes, clients can use other measures to evaluate the contractors competitiveness by requesting information such as:

- Profit percentage
- Offsite overheads
- Daywork rates
- Draft programme
- Contract price adjustment proposals

By keeping stage 1 open book, agreement on risk allocation and competition in the supply chain will normally ensure that the contractor's price remains competitive. Under this arrangement the contractor should only be paid at cost through stage 1 (this will include designers working for the contractor, who will also be charging at reduced rates).

There should always be a get out clause for both parties at the end of stage 1 in the unlikely event that agreement cannot be reached prior to advancing to stage 2.

6 BUILD OWN OPERATE

A BOOT funding model involves a single organization designing building, funding and operating a scheme for a defined period of time before transferring ownership to the client. Parties enter into long term supply contracts and are charged for the level of service received. The service charge includes capital and operating cost recovery and project margin. If there is no service there is no charge.

BOOT schemes are becoming an increasingly popular means of financing large scale infrastructure developments such as water and wastewater treatment. There are several large scale BOOT projects in tender in Australia including Mundaring Weir. The BOOT model is effectively 100% debt funding. End users pay no upfront capital costs but are committed to regular water charges. The capital cost is repaid over the term of the supply contract.

6.1 ADVANTAGES AND DISADVANTAGES OF BOOT

6.1.1 ADVANTAGES

- The majority of the construction risk can be transferred to the service provider
- BOOT projects allow development to happen very quickly. The scheme is not constrained by a lack of funding, a lack of expertise or project management capability. Also, there are strong incentives for the contractor to complete construction and get the scheme into operation as soon as possible.
- No upfront costs for water users free up capital for other public works.
- Accountability for the asset design, construction and service delivery is very high given that if performance criteria are not met, the operator stands to lose a portion of capital expenditure, capital profit, operating expenditure and operating profit.

6.1.2 DISADVANTAGES

- Community and particularly water users may have a negative reaction to private sector involvement
- A rigorous selection process is required when selecting a BOOT partner. Client organizations need to be confident that the BOOT operator is financially secure and committed to the New Zealand market prior to considering their bid.

7 CASE STUDY SCOTTISH WATER

Scottish water recognized the needs for a radical change in procurement approach when it faced the challenge of delivering on its Capital Investment Programme from 2002 to 2006. The water industry had suffered from decades of underfunding and neglect. Following the almagamation of the three previous water authorities, Scottish Water inherited a large number of ageing assets, many of which were built in the 19th century but which were expected to serve the demands of the 21st century. In 2002, 78 wastewater treatment plants failed compliance and 40% were deemed unfit for purpose.

The infrastructure network of water mains and sewers was particularly bad with 60% of it being in poor or very poor condition. In 2001/02 there were over 9,000 bursts. In addition given the scale of the construction programme, a more radical approach than had been seen before was required for managing health and safety. The civil construction industry in Scotland had one of the worst safety records in the UK. This factor alone had delayed delivery of projects in the past and involved costly claims. Following a consultation exercise it was established that 5 billion (NZD) of investment in water quality and wastewater treatment was required to meet European Union regulatory standards. The Water Industry Commissioner for Scotland (WIC) advised that, by achieving economies of scale from a merged Scottish Water and by pursuing asset delivery as efficiently as elsewhere in the UK, the programme could be delivered for 3.5 billion – delivering significant savings to Scottish Water customers.

Scottish Waters response was to set up Scottish Water Solutions – a new kind of capital investment delivery model.

The Solutions' Partnership is composed of Scottish Water, which is the majority owner with 51% of the shares in Solutions. The balance is shared equally by two consortia; UUGM Limited comprising United Utilities with their construction partners GallifordTry and Morgan Est and Stirling Water Limited, composed of Veolia Water UK with their construction partners Black and Veatch, KBR and Alfred McAlpine.

From day one, initiatives were introduced to develop the partnering ethos within the new Solutions' 'Delivering More for Less' corporate culture and to extend it from the In-House Delivery Partners to key suppliers, design and Associate Delivery Partners.

Partnering events, Best Practice Forum, Supply Chain Workshops, a Design Principles Panel and co-location encouraged issues to be aired and resolved and skills and knowledge to be transfered amongst partners in order to drive further efficicencies from the delivery of the Programmes.

This has included delivery partners being involved at the early stages of a project to input practical construction needs into designs.

These initiatives underpinned the 'pain-gain' arrangement which means that financial rewards only come to the Partners when the Programmes are delivered for less than the target cost: the partnership model is the first of its kind in the water industry where client, consultants and contractors collaborate together on a jointly incentivised basis.

The incentivisation model has also meant that the Programmes have not been dogged by the claims culture inherent in much of the construction industry, a remarkable achievement given the scale and pace of delivery.

In 2006, a joint Scottish Water/Solutions' Close Out Team was established to manage the huge task of handing over hundreds of projects completed in Q&S II. This drew on the partnership approach to bring focus to specific risks around documentation and telemetry.

The success of partnering in Solutions and the willingness of large contractors to share information with former competitors and smaller contractors has also brought about a wider cultural change in the Scottish construction industry.

8 CONCLUSIONS

It is obvious from industry experience that there is shortcoming with existing contractual relationships and that these have a negative effect on project outcomes. Many existing contractual relationships, particularly traditional forms, lead to adversarial behaviour which also has a negative effect on project outcome.

The industry needs to improve the way it goes about business and clearly change is required to improve efficiencies and lower costs across the whole life cycle of construction projects.

Constructability requires that client organizations go beyond conventional approaches to project execution by expanding front end planning and design and address issues that may impact the successful completion of the project. By working together in a collaborative manner and introducing contractors at an earlier point in the construction process than has traditionally been the case the following benefits can be gained:

- Satisfied Communities
- Good predictability/quality/cost
- Fair return on investment for all

ACKNOWLEDGEMENTS

Opinions expressed in this paper are the opinions of the relevant contributors. Downer NZ does not necessarily share these opinions.

REFERENCES

Latham, Sir Michael (1994) *Constructing the Team* HMSO

Egan, Sir John (1998) *Rethinking Construction* HMSO

Robertson, Derek Personal Communication

Scottish Water

Australian Constructors Association