IMPLEMENTING INNOVATION THROUGH VALUE ENGINEERING - OBSERVATIONS ON U.K. CIVIL ENGINEERING CONTRACTORS

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The construction industry has often disappointed its clients by producing buildings and infrastructure projects that are late, over budget and littered with defects. In an attempt to rectify the problems the U.K. Government has sponsored many reports which have all had the aim of securing improvement in the sector.

Various guidelines have been produced by organisations such as the Building Research Establishment (BRE), the Office of Government Commerce (OGC), the Construction Industry Research and Information Association (CIRIA) and the Constructing Excellence (CE) programme. In addition to the guidelines, a series of case studies have been published which demonstrate that significant improvement can be achieved by implementing value management. Value management is taken as an umbrella term embracing the three processes, namely: value planning, value engineering and value reviewing. This research concentrates on the practical applications of *value engineering* which is defined as 'a systematic approach to delivering the required functions at lowest cost without detriment to quality, performance and reliability'.

The majority of literature and best practice guidance reports and recommendations on value management are aimed at large clients particularly those in the public sector. The aim of this investigation is to determine how the best practice guidance reports have been received and implemented by construction contractors within the U.K.

Following a comprehensive literature review into value engineering a structured questionnaire was developed and fourteen structured interviews were undertaken with senior representatives of a wide range of construction contractors.

The findings of the investigation identified that contractors' detailed knowledge on the U.K. Government sponsored value management guidance reports was limited. However, in practice the principal recommendations within the guidance reports have been successfully implemented by contracting organisations on a wide range of projects to the benefit of both the contractors and their clients. The modern procurement systems, which are based on long-term framework agreements or Early Contractor Involvement as practiced by the Highways Agency, should encourage value engineering and continuous innovation from contractors and their supply chains.

Keywords: Value management, civil engineering, contracting, U.K.

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INTRODUCTION

Cartlidge identifies that 'The construction industry was in many ways letting its clients down by producing buildings and other projects that were, in a high percentage of cases, over budget, over time and littered with defects' (2002).

In an attempt to rectify the problems within construction the U.K. Government sponsored several reports which all had the aim of improving various aspects of the industry. Ashworth and Hogg (2000) comment that 'the underlying theme in all of them has been an attempt to provide better value for money for the clients or customers of the industry'.

Guidance documents on value management include:

- ICE Design and Practice Guides: 'Creating Value in Engineering' (ICE 1996)
- CIRIA Special Publication 129 'Value management in construction: a client's guide' (Connaughton & Green 1996)
- Building Research Guidance Publications
    - 'Value from Construction: Getting started in value management' (BRE 2000a)
    - 'Value workshop: concise guidance on the value management workshop' (BRE 2000b)
    - 'FAST approach: function analysis and diagramming techniques' (BRE 2000c)
- Constructing Excellence 'Value Management' fact sheet' (CE 2004)
- Achieving Excellence in Construction Procurement 'Risk and Value Management Guide 04' (OGC 2007a).

In addition to the guidelines, a series of case studies have been published which demonstrated the benefits of implementing value management (OGC 2007b). In the main both the guidance notes and the case studies tended to focus on government run projects with large project teams. There appears little reported documentation on contractors in the private sector initiating the value engineering process themselves.

VALUE MANAGEMENT (VM)/VALUE ENGINEERING (VE)

Value management is considered an umbrella term embracing value planning, value engineering and value reviewing. This investigation concentrates on value engineering which is defined as 'A systematic approach to delivering the required functions at lowest cost without detriment to quality, performance and reliability' (Connaughton J.N. and Green S.D. 1996).

Essentially value engineering can be described as a process which eliminates unnecessary costs i.e. identifying an alternative option which provides the same function but at a lesser cost. This is confirmed by Dell'Isola (1997) who states ' The VE process identifies opportunities to remove unnecessary costs while assuring that quality, reliability, performance, and other critical factors will meet or exceed the customer's expectations'.

Kelly, Male and Graham (2004) consider that 'Value management has a business focus and is strategic in nature whilst value engineering, a subset of value management has greater technical focus'.

Constructing Excellence (2004) introduces whole life costing into the equation stating 'Value management incorporates value engineering which is a systematic approach to delivering the required functions at optimum whole life cost without detriment to quality, performance and reliability'.

The OGC (2007) captures the essence of what is actually involved in the process stating 'Value engineering is a continuous process in which all the components and processes involved in construction are critically appraised to determine whether better value alternatives or solutions are available'.

Value engineering can thus be said to have the following features: has a technical focus; involves using value techniques; selects the most cost effective solutions to achieve the required function; removes unnecessary costs; reduces construction time and improves quality and maintainability.

Many of the U.K. standard forms of contract do not, at first sight, embrace value engineering incentive schemes - often a bespoke contract will have to be drawn up, or a standard form amended. In an international context it is noted that Sub-clause 13.2 'Value Engineering' within the FIDIC Conditions of Contract for Construction 'Red Book' (FIDIC, 1999) encourages the Contractor to submit written proposals which may *'(i) accelerate completion, (ii) reduce the cost to the Employer of executing, maintaining or operating the Works, (iii) improve the efficiency or value to the Employer of the completed Works, (v) otherwise be of benefit to the Employer.'* If the Engineer approves the changes, then the Contractor will receive 50% of the net saving.

Based upon the findings in the literature review, the following a*ssessment criteria* was used to determine whether the examples given by the candidates were in fact 'true' value engineering:

a) The study must be multi-disciplinary (i.e. involve both client and contractor)
b) The function of the component / element in question must be identified correctly
c) The existing solution must be identified
d) An alternative solution must be identified
e) The alternative solution must perform the same function
f) The client / end user requirements must be maintained
g) Unnecessary costs must be eliminated, and
h) Appropriate techniques must be used.

RESEARCH METHOD

The technique of personal interview based on a pre-determined set of questions was adopted for this research. This approach enabled the interviewer, the first author, to have full control of interview and gain a deeper understanding of the topic investigated.

Following the comprehensive literature review a questionnaire was developed comprising a mixture of quantitative closed-ended and multiple choice questions and qualitative open-ended questions. Fourteen representatives of the contracting construction industry were interviewed. The participants ranged in job title and size of the company they worked for ranging from small to large. As part of the process each interviewee was issued with an 'information sheet' and a 'consent form'. All interviews were audio recorded and then transcribed into a written format

ANALYSIS OF RESULTS

Interviews: General Information

The majority of the fourteen contractors' representatives who were interviewed were employed by companies with a turnover of over £100 million, closely followed by those employed by companies with a turnover of £60 - £100 million. Most of the candidates interviewed were directors with the remainder being employed as quantity surveyors, design managers, bid managers and a regional manager.

Furthermore, the majority of the candidates interviewed were employed by companies which undertook major civil engineering projects. This was closely followed by those who were employed on small civil engineering works, commercial property, housing, residential and refurbishment work.

Interviews: Understanding of value engineering

Between them, the candidates produced quite a definitive list of key words / themes which related to value engineering. When compared to the research within the literature review regarding the definition of value engineering, none of these definitions were incorrect. However, some of the key ideas that were not mentioned by the candidates include the following: it involves using value techniques; construction time can be reduced; quality and maintainability can be improved and it requires a multi-disciplinary approach.

Interviews: Experiences of value engineering – setting the context

In this section the candidates were asked to think of a project in which they had participated in a value engineering study and to base all of their answers within this section on that case study. All the examples of value engineering identified by the candidates, bar one, were undertaken by large contractors (i.e. with a turnover of over £60m and over 100 employees). In addition, the majority of the projects undertaken were of a major civil engineering nature closely followed by commercial property.

The results show that the majority of the value engineering examples given during the interviews were undertaken on roads projects, closely followed by bridges. The remainder of the examples related to commercial property, drainage, structures and housing. The traditional procurement route and the design and build route were used as frequently as one another. private finance initiative (PFI) and early contractor

involvement (ECI) were used once and partnering was used twice (once with the traditional route and once with the design and build (D&B) route).

Under ECI, which has been adopted on major U.K. public highway projects, the contractor joins the team at the start of the *statutory process*. A target price is developed on an open-book basis and the contractor is incentivized to design and construct the scheme on a pain/gain formula (Bishop 2007). The early involvement of the contractor and the supply chain require joint identification and management of risk during the design stage, lead to shorter construction periods and the avoidance of disputes due to collaborative working. Further the ECI approach allows more scope for innovation, facilitates value management and value engineering and minimizes claims and is encouraged by the National Audit Office (NAO) and Office for Government Commerce (OGC) (Nichols, 2007)

The most frequently used form of contract was the NEC (Option C – Target Contract with Activity Schedule) (NEC 1995) closely followed by the JCT (With Contractors Design) (JCT 1998). Both of these contracts allow the contractor to influence the design and therefore undertake value engineering. Obviously contractors on a D & B project will have full reign on the design as long as it remains compliant with the client's requirements. Under clause 53 of the NEC Option C contract the contractor is encouraged to generate value engineering proposals under the pain/gain mechanism. The results show that 6 of the 14 examples given had a value engineering incentive inserted into the contract all procured based on the NEC Option C form of contract.

The results show that just under half (6) of the examples given were undertaken post contract award, but prior to construction. This was closely followed by examples given during tender stage (5). There were very few (3) examples given for value engineering undertaken during the construction phase. This supports the findings in the literature review that it is recommended that a value engineering study is carried out as early in the project cycle as possible.

The vast majority of the value engineering studies were initiated by the contractors. Only 3 out of the 14 examples were initiated by the client. The most frequent reason for initiating the value engineering study was to benefit both the contractor and the client. Only 1 example was to benefit just the client and only 3 examples were to benefit the contractor only.

The main trigger for undertaking the value engineering study was because it forms part of the contractor's procedures as a matter of course. This could be either during tender stage where the contractor devises alternative solutions in order to help win the job; or during construction when the contractor is constantly reviewing the existing design for alternative solutions.

One candidate said the trigger for his value engineering study was to "firstly win the project and save time for the client". Another candidate said that his value engineering study was triggered by the realization that the current design "didn't seem the right solution. It didn't fit the existing surroundings". A further candidate said that the trigger for his value engineering study was because it is "part of the tender philosophy of the company. It was always going to happen. We are constantly looking for new ideas".

Interviews: Experiences of value engineering – examples

The majority of the examples given by the interviewees were found to be true value engineering (i.e. complying with the researcher's assessment criteria in Section 2 above). However, in some cases the team involved in the value engineering study was not multi-disciplinary - the client was not listed as one of the parties involved in the initial discussions.

Examples of VE to benefit the contractor only

Contractor number three said "We mainly look at works associated with excavation, disposal and how to minimize the quantity. We aim to maximize the benefit by ground remodelling mainly on earthworks whilst still delivering the required product to the client" He gave an example of when his company undertook value engineering for the benefit of his company only. He was undertaking an earthworks project and rather than dispose of the inert muck off site, he obtained permission off the client to dispose the muck on site. This was pitched to the client on the basis of forming the muck into unobtrusive landscaping which gave a visual and aesthetic improvement to the site. This generated a significant margin for the contractor whilst improving the aesthetic quality of the site, and without detriment to the original function of the project.

Contractor number six gave an example of a study which was undertaken during the construction phase and focused around the drainage design. This was a D&B contract and the original design was to use concrete pipes. The contractor came up with an alternative solution to use glass reinforced plastic pipes which are not only cheaper to purchase, they are also cheaper to install as they do not require lifting equipment. Although the client was not involved in the value engineering study itself, the function of "provide drainage" was maintained. However, the client did not benefit from the reduced cost.

Contractor number eight said: "There is a minimum amount of value engineering that can be carried out at tender stage due to time restrictions. We will generally win a job because of the limited amount of value engineering that we have been able to do at tender stage. Then we will target internally to make more money whilst maintaining the client's requirements." He gave an example of when his company undertook a project on a lump sum D&B basis. The original design, and therefore contract sum, included for lime stabilization of the ground. Upon further investigation, it was found that the ground did not require lime stabilization. However, the contractor was still paid for lime stabilization as it was a lump sum and they were responsible for the design. He also said that "sometimes things go the other way and positives like this example are needed to outweigh the negatives."

Examples of VE to benefit the client only

Contractor number three gave an example of a study undertaken at tender stage where the function in question was to "stabilize ground" due to the large quantity of alluvial clay. The design proposed by the client was to excavate and replace the clay. The

contractor came up with an alternative solution which was to vibro-compact the clay, thus saving money and time. This was proposed to the client with the contractor's tender bid on a shared saving basis (65%/35% in favour of the client). Interestingly, (according to the contractor) the client let the tender period elapse and then issued revised tender documents based on vibro-compaction. However, the contractor's company was not on the revised tender list. Although the client was not involved in the initial value engineering study itself, the function of "stabilize ground" was maintained.

Contractor number nine offered an example regarding a housing scheme. This contract was let on a D&B contract and the value engineering study was carried out during phase 2 of the tender process. The original tenders were £1m over budget; therefore the client initiated a value engineering study. One function which was looked at during the study was "retain earth". The original solution was complex pre cast concrete retaining walls. A number of possible alternative solutions were generated by the value engineering team using brainstorming. The alternative solutions suggested were gabion baskets and other structures. The most suitable alternatives were designed further and entered into a function cost matrix. Planning issues were also taken into consideration and so was the impact on the 'sale ability' of the housing. The solution that was eventually selected was to raise the ground levels of the site, thus reducing the need for complex and tall retaining walls. Instead, shorter, less complex pre cast concrete retaining walls were installed. This generated a saving of about 7% which was all taken by the client. The candidate who was interviewed said that "the win for us was to get the work".

Examples of VE to benefit the client and contractor

Contractor number four gave an example of a study undertaken at tender stage which focused around the traffic management scheme. The scheme proposed by the client was complex and the contractor came up with an alternative solution which would omit one phase of the traffic management, thus saving money and time. This was proposed to the client with the contractor's tender bid and the alternative scheme went ahead. Although the client was not involved in the initial value engineering study itself, the function of "safe passage of traffic" was maintained and the client benefited from the reduced cost.

Contractor number six offered an interesting example regarding the installation of a cycle path in a rural area, away from any roads or traffic. The function of the footpath was to enable cyclists to get from point A to point B. This contract was let on an NEC Option C with a pain/gain mechanism and therefore the contractor was always looking for ways to reduce the target cost. The original design incorporated edgings with a concrete bed and haunch either side of a tarmac path. The contractor believed that the edgings were an unnecessary cost as the path would still function without them as there is no danger of nearby heavy traffic. The client initially believed that this was not value engineering and that the contractor just wished to omit a specified part of the design to cut costs. The contractor then explained that the path would still be performing the same function, the design would be more rural and suit the surroundings better and that the overall costs would be less. The client was persuaded

and the alternative solution went ahead and approximately 15% was saved on the cost which was shared equally between the client and contractor.

Contractor number thirteen offered an example regarding a highway scheme that required the function of a "transport link from one side of a valley to the other". This contract was let on an NEC Option C with a pain/gain mechanism and therefore the contractor was always looking for ways to reduce the target cost. The original design was a viaduct from one side of the valley to the other. The interview candidate said:

"Building a viaduct would cut the construction site into two sections for a considerable period of the construction programme. Because of the steepness of the valley, bulk earthworks materials from the eastern end of the contract would have to travel by road wagon, on the existing A30, which was already over capacity. Following detailed analysis it became clear that considerable site clearance outside the structure's footprint would have to be cleared to allow access for craneage and construction of hardstandings."

The value engineering team carried out a brainstorming session and came up with an alternative solution which was to strengthen the embankment rather than install a new viaduct. The interview candidate said that this solution was selected because "Early access through the project on site haul roads could be provided. All earthwork materials could be moved using heavy earthworks equipment off the public road. It was a safer option to construct and the construction programme was improved."

The strengthened embankment still performed the function of a "transport link from one side of a valley to the other". Savings of circa £600k were generated which equated to 15%. The savings were shared between the client and contractor as part of the pain/gain share mechanism.

CONCLUSIONS

The research aimed to determine how the best practice guidance reports have been received and implemented by civil engineering contractors in the U.K. The research has established the general rules that value engineering is almost always justified on projects of high value and high risk. It is confirmed that a multi-disciplinary team produces better results than an individual acting alone. Furthermore, it is preferable to undertake a value engineering study as early in the project as possible because the cost reduction potential is higher and the cost to implement design changes is lower. The following detailed conclusions were also established:

- Contractors have a thorough understanding of what value engineering means despite not being overly familiar with the details of the VM best practice guidance notes.
- Contractors can demonstrate when they have undertaken true value engineering.
- Some of the value engineering examples failed the test as the client was not involved; however, the function and the client's requirements were maintained.

- The most frequently used procurement routes allow the contractor to initiate value engineering.
- The majority of the studies are initiated by the contractor for the benefit of both the contractor and the client as part of the contractor's normal procedures.
- Value engineering was often initiated at tender stage to enable contractors to win the contract within the client's budget.
- The contractors would rather generate savings for themselves than the client; however this is only the case when function or quality would not be adversely affected.
- Clients need to be more involved in the value engineering process and better understand their role as the definer of value.

The findings of the investigation identified that contractors' detailed knowledge on the U.K. Government sponsored value management guidance reports was limited. However, in practice the principal recommendations within the guidance reports have been successfully implemented by contracting organisations on a wide range of projects to the benefit of both the contractors and their clients. The modern procurement systems, which are based on long-term framework agreements or Early Contractor Involvement as practiced by the Highways Agency, should encourage continuous innovation from contractors and their supply chains.

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