2013-04-25

Developing a Standard Approach to the Value Engineering Process for the Civil Engineering Industry: a Theoretical, Case Study and Industry Perspective.

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Recommended Citation

Jessup, S., Mitchell, C. (2013) :Developing a standard approach to the Value Engineering process for the Civil Engineering Industry: A Theoretical, Case Study and Industry Perspective. CEEC General Assembly Brussels 25-27 April 2013. doi:10.21427/h3zk-v709

Developing a standard approach to the Value Engineering process for the Civil Engineering Industry: A Theoretical, Case Study and Industry Perspective.

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Abstract: The original Value Engineering process developed in North America in the late 1940's, was primarily based on functional analysis. However; the North American Value Engineering process was not adopted in Europe. Instead various mixed methods were assembled under the umbrella term of Value Management. Nowadays there is much debate about what Value Engineering is and how is it defined? This question arises in part due to there being no standard approach in Europe as a whole in undertaking Value Management or Value Engineering exercises.

With this in mind, Masters level research was undertaken from three perspectives (theory, case study and industry). The research revealed inconsistencies between the theoretical perspective and the two other perspectives. To address these inconsistencies; it is proposed that perhaps, it is now time to revert to the original North American Value Engineering process of function analysis, with the addition of the constraints triangle (time, cost, quality). Perhaps this is the best starting point in developing as standard approach to the Value Engineering process in Europe. To understand if these inconsistencies are Europe wide or unique to the Irish market, the author intends to undertake PhD research with his present employer Ferrovial Agroman, on a Cross Rail contract in the UK.

Introduction: The role of European Value Engineering proposals within the civil engineering sector cannot be under estimated. It potentially can have a number of benefits to both client(s) and contractor(s). However, the process and potential outcome of any European Value Engineering proposal can vary considerably depending on either, or both, the geographical location of the project and the specific contract under which the project is being administered. The process of European Value Engineering proposals must not to be confused with the North American Value Engineering process as set out by S.A.V.E (Society of American Value Engineers). European Value Engineering is typically a sub group of the overall Value Management process. Kelly et al., (2002) describe how "Value Engineering opportunities commence at the stage when the project can be defined in terms of its elements and components and terminates upon the completion of the physical project" (p78).

To understand how a standard approach to Value Engineering can potentially be developed, it is important to understand the process and outcomes of Value Engineering proposals. If the Value engineering process and outcomes is understood, it paves the way forward to potentially finding one specific area within the Value Engineering process that need to be altered or needs to be focused on, in an effort to produce this standard approach. This specific area can then be developed into a standard approach; this can then be, used by both client(s) and contractor(s) irrespective of the geographical location of the project or the specific contract under which the project is being administered.

Research Methodology: The research aim was to produce a standard methodology to the Value Engineering process of Irish Civil Engineering Construction Stage Value Engineering Proposals, on projects which were being administered under the Irish Governments Public Works Contract for Civil Engineering Works (PWCF 03 & PWCF 04). One of the key objectives of the research methodology was to represent as many viewpoints as possible during the production of the standard methodology and so the research was carried out over four distinct phases. The chosen presentation format was a flowchart.

Phase 1 – Theoretical perspective: A theoretical perspective was developed from a detailed review of literature relating to the subject of Value Engineering. This literature

review was from a number of perspectives (geographical and industry). The outcome of phase one was a first draft of the standard methodology flowchart.

Phase 2 – Case Study perspective: The standard methodology flowchart brought from phase one was introduced to the live case study selected for the research. The case study was a 8 Km single lane road construction project across areas of peat land (up to 6 meters deep) that also included two bridge structures of 141 meters long (cast in situ extrostay design) and 210 meters long (cast in situ balanced cantilevered). The specific project was being administered under Irish Governments Public Works Contract for Civil Engineering Works designed by the contractor (PWCF 04) (design and build contract). The overall project presented many engineering challenges for the contractor and thus many opportunities for Value Engineering Proposals. The outcome of phase two was a second draft of the standard methodology.

Phase 3 – Industry perspective: The standard methodology flowchart from phase two was sent as part of a two question; questionnaire via email to eight key individuals (senior commercial managers / senior project manager) employed within Irelands largest Irish civil engineering contracting organisations. The questionnaire asked the respondents to review the standard methodology flowchart and for their comments on Value Engineering, within the context of an Irish road construction project using the Irish government's Public Works Contracts. The outcome of phase three was the respondent's proposed revisions of the standard methodology flowchart and their comments on Value Engineering process within the context of Irish road construction project using the Irish government's Public Works Contracts.

Phase 4 – Final review: The respondent's revisions to the standard methodology flowchart from phase three and the respondent's opinions on the subject of Value Engineering were incorporated into the final draft of the standard methodology. The outcome of phase four was the production of a final version of the standard methodology flowchart and an in-depth understanding of the Irish civil engineering Value Engineering process.

Literature Review: The literature review was undertaken in a number of sub sections, to track the progression of the Value Engineering process.

Value Engineering Origin: Laurence Miles has been acknowledged by authors such as (Kelly and Male, 1993), (Norton and McElligott, 1995) (Institution of civil, 1996), (Dell'Isola, 1997) as being the founding father of value engineering. Miles was employed in the purchasing department of the General Electric Company and was tasked with taking advantages of the new processes, materials, and techniques developed during the Second World. (Green, 1991) describes how the task given to Laurence Miles as being "if we can't get the part, then we must get the function". (p10). (Dallas, 2006) describes the logic of miles rethink, "instead of asking the question 'how can we find alternative sources of materials' he (Miles) asked 'what function does the component perform and how else can we perform that function" (p11).

Value Engineering in North America: Laurence Miles went on to form S.A.V.E (Society of American Value Engineers) with a number of other individuals in 1959. Miles early Value Engineering was based on his 1961 Job Plan. Palmer et al. (1996) noted that Miles early 1967 technique of Value Engineering "was fundamentally a broad philosophy which, by a questioning approach to processes, systems and components, sought alternatives based on the examination of function" (p324). Stage four of Miles Job Plan was later enhanced with the development of the Functional Analysis System Technique (FAST) diagram developed by Charles W. Bytheway in 1964. By the 1970's Miles early work had been developed into a three pronged process carried out in the confines of the Miles Job Plan with the FAST diagram.

The early Job Plan with the FAST diagram was typically applied to the manufacturing industry but this industry did not confine it to any specific time frame or to any specific

stage of the production process. However, when the Job Plan and FAST Diagram was introduced into the North American construction industry a number of changes occurred. The construction industry limited the time frame for the Job Plan and FAST Diagram to a forty hour workshop and typically restricted its use to the design / scheme stage with the use of a secondary design team.

Value Engineering in the UK: The actual date for the introduction of Value Engineering into the UK has been outlined in a number of texts. However Dallas, (2006) proposes that its introduction date was in 1983, when Value Engineering was used for the first time by the American company Xerox on its new UK headquarters building. The North American Value Engineering process was adopted in the UK on a modified basis rather than on franchise basis. This adoption resulted in a number of modifications to the Value Engineering process. Kelly and Male (1993) were one of the first researchers and authors on a UK Value Engineering process suggested the following four stage Value Engineering process, with stage one using functional analysis and stage three using the Job Plan

1. Functional Analysis
    - The proposed functional analysis is based on a four level analysis
        - Project Task
        - Spaces
        - Elements
        - Components
2. Life Cycle Costing
3. Multi –Disciplinary Work group
    - Work groups utilising the Job Plan and creative techniques
4. Establishing Comparative Cost
    - Establishing a comparative cost in relation to the function and hence overtly concerned with issues of value.

Kelly et al (2002) outlined earlier that Value Engineering opportunities commence at the stage when the project can be defined in terms of its elements and components. Ellis et al., (2005) outlines that elements and components overlap each other but start at scheme design stage and finish at the completion of site operations

The North American model also focused mainly on the workshops taking place at sketch / design stage. However; Connaughton and Green (1996) suggest that there should be a number of workshops based upon ‘opportunity points’ within the job progression. Kelly et al (2002) suggests five workshops with specific durations of these workshops.

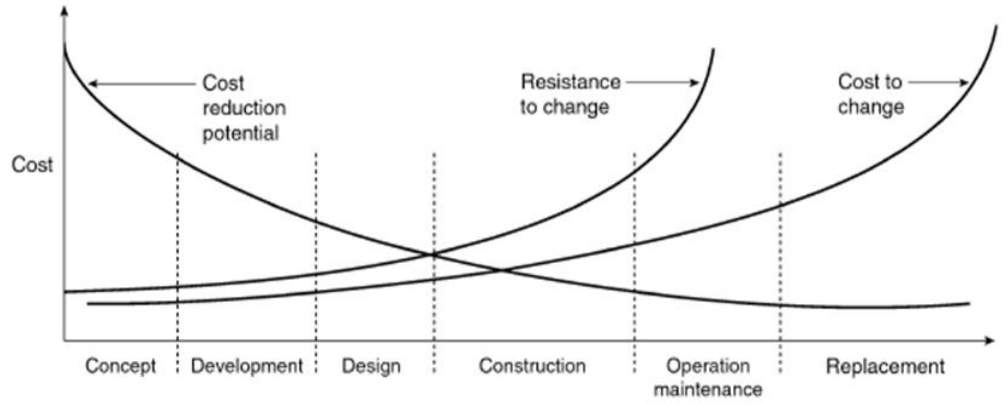
1. The Pre Brief workshop
    - Duration: open
2. The Brief workshop
    - Duration: 1 to 2 days
3. The Concept Design workshop
    - Duration: 1 to 2 days
4. The Detailed Design workshop
    - Duration: open
5. The Implementation workshop
    - Duration: 1 and a half days

However; Ellis et al., (2005) commented that while the one day workshop had been previously been commonplace, the workshops have been now reduced to half day, or even 2 hour workshops.

The F.A.S.T diagram was retained by some in the adoption of the North American model, such as the British Standard for Value Management (12973-2000), but a number of authors suggest alternatives to the F.A.ST diagram or even the removal of the diagram entirely from the process.

The final issue remaining in the adoption is the use of secondary design teams in the workshop stage(s). Connaughton and Green, (1996) identify the potential dangers of the use of secondary design teams auditing the design with the following; "the danger is that such a group (second design team) may come into conflict with the existing design team. It is often more effective therefore to use the existing design team, supplemented as necessary by 'external' expertise" (p42).

Value Engineering in the UK & Irish Construction Industry: The stages for the application of Value Engineering within the construction industry above does not identify where Value Engineering can have the most benefit(s). The potential benefits of Value Engineering can reduce as the project progresses, due to the cost of implementing changes arising out of a Value Engineering exercise. Hayles and Simister, (2000) provides a graphical representation of how the cost to change increases as the project processes and the potential for cost reduction decreases.



The other issue surrounding the implementation of Value Engineering within construction industry is the issues surrounding Cost, Value and Function. There are a number of mathematical representations for the interaction between cost, value and function.

$$\text{Value} = \frac{\text{Function}}{\text{Cost}}$$

- Function: The measurement expressed in currency, effort or exchange
- Cost: The price paid or to be paid

FUNCTION: Kelly et al., (2002b) noted that functional analysis has now only become a stage in the overall Value Engineering process, rather than a core activity. Hayles and Simister, (2000) give a simple example of functional analysis by stating that, a functional analysis "attempts to explore function by asking 'what must it do' and 'what does it do' and then identifying the most cost effective and most valuable way of achieving the key function" (p6). However Institution of Civil, (1996) explains that Function is 'the purpose or use of something' and is a fundamental aspect of Value Engineering and that the Value Engineering team will use a list of five questions to determine its value. (p23)

1. What is the purpose of the project or element?
2. What does it do?
3. What does it cost?
4. What is it worth?
5. What else could do the job?

VALUE: Kelly, (2007) noted that the definition of value has being the subject of much debate. Kliniotou, (2004) explains that value can also take a number of forms

- Exchange Value The open market price of an item
- Use Value The usefulness value of an item
- Esteem Value The attractiveness or desirability of an item

Dallas, (2006 explains that value is often synonymous with cost and that understanding that the value of an item is not what they are, but what they do. The author also explains that the value of an item lies in what an item brings to the project and not what they are. Dallas, (2006) summarises the situation best in relation to value with the following "Value Engineering is about delivering more of the right things for less resources" (p14).

COST: Potts, (2008) provides a comprehensive list of five specific causes of unnecessary costs.

1. Cost - Unnecessary attributes
    - Failure to examine attributes which cause no useful function
2. Cost - Unnecessary specification
    - Failure to examine specifications due to needlessly expensive materials/components
3. Cost - Poor build ability
    - Failure to consider construction implications during design
4. Cost – Lifecycle
    - Failure to consider future operational costs
5. Cost – Opportunity
    - Failure to consider the cost of losing potential revenue

Dell'Isola, (1997) summarises the relationship between cost, value and function with the following "it is important to avoid confusing cost with value. If added cost does not improve quality or the ability to perform the necessary functions, then value is decreased" (p xix).

Value Engineering in public sector road construction in Ireland: The Irish Government launched the National Development Plan (NDP) in late 1999. The 2000 – 2006 N.D.P had an investment of 6.0 billion in road construction. However: upon completion of this N.D.P cycle, the Irish Government encountered problems with the late delivery of project and major cost overruns. To overcome these problems, the Irish government saw the need for the following reforms.

1. A standardised national contract for all public works.
2. A move to 'Design and Build' and PPP (Public Private Partnership) contracts.

These reforms resulted in the following,

- The introduction of the Irish Governments model form of contract in 2007 (PW-CF) 1-7.

The Irish government model form of contracts used for, employer designed, 'Design and Build' and PPP, road construction are

- PW-CF3 : Public Works Contract for Civil Engineering Works designed by the Employer
- PW-CF4: Public Works Contract for Civil Engineering Works designed by the Contractor

In both contracts Value Engineering is contained in clause 4.8. But the wording of clause 4.8.1.2 differs between the two contract types

PW-CF3:

4.8 Value Engineering

4.8.1

The contractor may give to the Employer's Representative a written Value Engineering proposal that will, if adopted, either

(1) reduce the Contract Sum or

(2) accelerate the execution of the Works, or otherwise be of benefit to the Employer, with no increases in the Contract Sum

PW-CF4:

4.8 Value Engineering

4.8.1

The contractor may give to the Employer's Representative a written Value Engineering proposal that will, if adopted, either

(1) reduce the Contract Sum or

(2) accelerate the design or execution of the Works, or otherwise be of benefit to the Employer, with no increases in the Contract Sum

When the Irish government introduced the PWCF contracts they also produced a number of supporting publications. The most notable of these publications that relate to construction stage Value Engineering proposals in civil engineering projects was the following:

- Capital Works Management Framework, Guidance Note: Implementation Process, GN 3.1
- Public Works Contracts, Training Manual

The National Roads Authority who produce and maintain the standard(s) for road and bridge construction in Ireland from procurement stage to final handover and beyond into the maintenance cycle, also published guidance material; again the most notable of these where the following:

- National Roads Authority Contract Administration Guidelines July 2010
- National Roads Authority Cost Management Manual March 2010
- National Roads Authority, Project Management Guidelines January 2010

Findings and Analysis:

General Information

- The two question questionnaire was sent to eight respondents.
- The questionnaire was returned by 85% or seven out of the eight respondents.

The theoretical perspective was analysed and broken down into twelve questions to allow the respondents comments to be analysed. The twelve questions where then used as a method to discuss the theoretical perspective against the case study and industry perspective. The twelve questions developed where the following:

'Did the respondent comment on'

1. Identifying the function of the element/component?
2. Seek to replace the element or component?
3. The early construction stage introduction of Value Engineering?
4. Following the Job Plan?
5. Following the FAST diagram?
6. The 40 hour workshop?
7. The 2 hour workshop?
8. Examining all or certain aspects of the design?
9. Clause 4.8 of the Public Works Contract?
10. Reduction in the contract sum?
11. Accelerating the design or execution of the works?
12. Other benefits to the employer?

Identify the function of the element/component.

- **Theoretical perspective:**

Hayles and Simister, (2000) describes that functional analysis: "attempts to explore function by asking 'what must it do' and 'what does it do' and then identifying the most cost effective and most valuable way of achieving the key function" (p6).

- **Case study and Industry Perspective:**

The identification of the function of the element/component within the overall VE process is the foundation or the base building block for the entire VE process. The importance of identifying the function of the component or element cannot be underestimated.

Seek to replace the element or component

- **Theoretical perspective:**

The replacement of an element or component is the subject of much debate and there are two types of lenses in this debate. The narrow lens seeks the replacement for cost reasons only, while the broad lens seeks replacement for value reasons.

- **Case study and Industry Perspective:**

The case study, highlighted that, simply trying to replace an element or component on cost alone is unwise. In some circumstances it may be the case that the replacement of a new component or element proposed in a Value Engineering proposal may come at an additional cost, rather than a reduced cost.

Early construction stage introduction of VE

- **Theoretical perspective:**

Kelly et al., (2002b) notes that there are a number of opportunities for VE "but that the earlier it is introduced within the project cycle, the greater the potential impact" (p484).

- **Case study and Industry Perspective:**

The theory is that Value Engineering should be introduced as early as possible. However: civil engineering projects typically contain a large amount of unknowns. Seeley and Murray, (2001) commented that civil engineering construction typically "involves elements of uncertainty, as for example the excavation work." (p6). The case study revealed that Value Engineering proposals should be verbally discussed with the client well in advance, in what can be described as 'kite flying' exercises to obtain the clients thoughts on a particular proposal. If the client's thoughts on the proposal are positive, then the formal Value Engineering proposal can be progressed to a stage that it is ready to send. If the conditions on site that are expected for a particular Value Engineering proposal materialise, then the VE proposal can be sent to the client, with some degree of certainty that it will progress smoothly and a decision will be delivered just as the site needs the change proposed.

Follow the Job Plan & Follow the FAST diagram

- **Theoretical perspective:**

Miles original Job plan was later enriched with the inclusion of the FAST diagram in phase four of the seven stage job plan. It is suggested that the job plan's seven stages should be followed in strict sequence and not to be 'dipped in and out of' or 'dabbled in'.

- **Case study and Industry Perspective:**

The research revealed that the use of the job plan and FAST diagram for construction stage VE proposals is a complex task to undertake. An analysis of the research would propose a revised Job Plan based on the Miles original Job Plan (above) and that it would reflect a more practical / applicable Job Plan for construction stage VE proposals.

Phase 1: Orientation and Specification

- Functional Analysis
- Alternatives to Function identified

Phase 2: Information

- Examination of: Cost &Time & Quality

Phase 3: Status Summary and Conclusion

- Presentation of findings: Time, Cost & Quality analysis

The 40 hour workshop & The 2 hour workshop

- **Theoretical perspective:**

Alalshikh, (2010) describes the 40 hour workshop as the review of the sketch design by the second design team. Ellis et al., (2005) commented that while the one day workshop had previously been commonplace, the workshops have been now reduced to half day, or even 2 hour workshops

- **Case study and Industry Perspective:**

The research revealed that the word workshop implies that it must be in some formal prearranged process and or format. However: the industry perspective revealed that they preferred a looser and informal conversation approach about a specific works item that is causing a problem / issue. The conversation, does not have to be formal, recorded or follow any format. The conversation can be as simple as, 'x works items is not doing the job that is needed' (function issue), or the x works item is over budget' (cost issue) or 'the x works item will take weeks / months of design and delivery time' (time issue) or 'the quality of the x works item is an extremely poor finish and the client will not accept it' (quality issue). Following on from this informal conversation, each member present can leave and resolve their part of the Value Engineering problem.

Examine all or certain aspects of the design

- **Theoretical perspective:**

Kelly and Male, (1993), comment that the North American VE Methodology was based on a 40 hour workshop to review the sketch design with the use of a second design team chaired by the value engineer.

- **Case study and Industry Perspective:**

The theory suggests that the design of the works item must be undertaken in some formal workshop, where a brainstorming process is undertaken to try and achieve an improved design solution (either cost, function, programme, quality), to the works item.

Clause 4.8 of the Public Works Contract

- **Reduction in the contract sum**
- **Accelerate the design or execution of the works**
- **Other benefits to the employer**
- **Theoretical perspective:**

The four sub headings are all interconnected with three being tied to Clause 4.8 of the public works contract. The theoretical perspective of clause 4.8 and its 'tied' elements are all contained in clause 4.8.1. Clause 4.8.2 is all about what the contractor's proposals should contain.

- **Case study and Industry Perspective:**

The theoretical perspective on the submission of VE proposals is one that portrays a simple and logical approach and requiring limited information to be submitted, and one supported in the approach of 'reciprocal co-operation' as described in Clause 4.1.1. However, the stark reality of VE proposals from a contractor's perspective is clearly evident in the case study. The research revealed the complexities of VE proposals from a cost, quality and programme aspect. The level of detail required to analyse the cost of one component against the other, requires a considerable amount of time.

Conclusion: The research has shown that the theoretical perspective of Value Engineering is subject geographical location and the contract under which the project is being administered. The North American process typically occurs at design/scheme stage in a forty hour workshop using a secondary design team. This Value Engineering process is tailored for the North American construction / civil engineering sector due to their favouritism towards of early contractor involvement. However, the European theoretical perspective is much more fractured with no one theoretical perspective has come to the fore. There are a number of suggested Value Engineering processes both from a theoretical and construction / civil engineering contract perspective. To overcome the problem of geographical location and contract issues it is suggested construction / civil engineering Value Engineering should focus on the following:

Function: (functional analysis) of components and elements: The research revealed that components and elements are typically removed or modified in any construction stage Value Engineering proposal.

TCQ: (Time, Cost, Quality analysis) of components and elements: The research revealed that a system needs to be developed to analysis components and elements in a systematic manner that can reveal the positives and negatives of any proposal. These positives and negatives can be used to 'sell' the proposed Value Engineering proposal to the client(s) or contractor(s).

On the final page is a suggested method for both client(s) and contractor(s) to undertake Value Engineering proposals.

References:

ALALSHIKH, M. A. S. 2010: The development of a value management approach for the Saudi public sector [electronic resource] [Online]. University of Leeds.

CONNAUGHTON, J. N. & GREEN, S. D. 1996: Value management in construction: a client's guide, Construction Industry Research and Information Association.

DALLAS, M. 2006: Value and risk management: a guide to best practice, Oxford, Blackwell.

DELL'ISOLA, A. J. 1997: Value engineering: practical applications --for design, construction, maintenance & operations, Kingston, Mass., R. S. Means.

HAYLES, C. & SIMISTER, S. 2000. The value workshop: concise guidance on the value management workshop, Building Research Establishment.

INSTITUTION OF CIVIL, ENGINEERING: 1996. Creating value in engineering, Thomas Telford.

ELLIS, R. C. T., WOOD, G. D. & KEEL, D. 2005: Value management practices of leading UK cost consultants. Construction economics and management, 23, 483-493

KELLY, J. & MALE, S. 1993a: Value management in design and construction
the economic management of projects, London ; New York, NY, USA, E & FN Spon.

KELLY, J. J. & MALE, S. 1993b: Value management in design and construction, the economic management of projects, Spon.

KELLY, J. J., MORLEDGE, R. & WILKINSON, S. 2002b: Best value in construction, Oxford ; Malden, MA., Blackwell Science.

KLINIOTOU, M. 2004: Identifying, measuring and monitoring value during project development. European journal of Engineering Education, 29, 367-376

PALMER, A., KELLY, J. & MALE, S. 1996: Holistic Appraisal of Value Engineering in Construction in United States. Construction Engineering and Management, 122, 324-328.

POTTS, K. F. 2008. Construction cost management: learning from case studies, New York, NY, Taylor & Francis.

SEELEY, I. H. & MURRAY, G. P. 2001: Civil engineering quantities, Basingstoke, Palgrave.

Suggested method to undertake Value Engineering proposals