

# APPRAISAL OF VALUE ENGINEERING IN DESIGN IN PORTUGAL

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Value engineering when effectively carried out during design process requires the value engineer to explore all value-added options within given constraints, without sacrificing the project quality and performance. This paper examines the value engineering practice in Portugal's construction industry by investigating theory and practice. A survey was conducted in the last months of 1998 of the largest design and project management organizations in Portugal to investigate the use of VE analysis in design. The survey indicated that 59% of the respondents use VE analysis and some had been using it for over ten years. The reasons why 41% of the respondents did not use VE analysis include the lack of formal guidelines and "not required" by their clients. In addition, this paper examines two case studies where the VE study was used. Most organizations assessed their VE analysis process as a successful or a somewhat successful operation.

Keywords: design, Portugal, value engineering.

## INTRODUCTION

Value Engineering (VE) is the title given to a set of value techniques applied during the design or 'engineering' phases of a construction project that has its origins in the US manufacturing industry. It has been instituted since Larry Miles introduced the concept in the late 1940s early 1950 (Norton and McElligott 1995). However, the concept first entered the construction industry in the early 1960s when VE incentive provisions were included in construction contracts. The application of VE during design phases of building projects has grown to such extent that it expanded beyond US borders throughout the world. At present, SAVE (1997) presents VE engineering as part of Value Management (VM) as a value methodology. A recent development in VM for construction industry (Connaughton and Green 1996) recommends that VM should incorporate VE.

Various researchers define VE in design as:

- "a systematic approach to delivering the required functions at lowest cost without detriment to quality, performance and reliability" (Connaughton and Green 1996).
- "a VE study attempts to identify unnecessary costs in design parts and components and suggest design alternatives (for those design items needing change) to reduce life-cycle costs without reducing the quality, function and performance of a building design" (de la Garza and Alcantara 1997).
- "is a management technique used to identify alternative approaches for satisfying the requirements of a project while lowering costs and ensuring technical competence in performance" (Acharya *et al.* 1995).

- “is the systematic effort directed at analysing the functional requirements of systems, equipment, facilities, procedures, and supplies for the purpose of achieving the essential function at the lowest total life-cycle cost, consistent with meeting needed performance, reliability, quality, maintainability, aesthetics, safety, and fire resistance” (Kavanagh *et al.* 1978).
- “as an organized approach in identifying unnecessary costs in design and construction and in soliciting or proposing alternative design or construction technology to reduce costs without sacrificing quality or performance requirements” (Hendrickson and Au 1989).

All these definitions indicate that VE is mostly based on economic aspects emphasizing techniques, such as functional analysis, brainstorming, weighted evaluation, life cycle costing. This paper uses the term VE to refer to the aforementioned definitions.

The construction industry typically applies VE analysis during the design and/or construction phases of a project. However, there is a greater potential for life-cycle cost savings, the earlier the VE analysis is conducted during the project life cycle (Hendrickson and Au 1989; de la Garza and Alcantara 1997; Mootanah 1998). VE concept first entered the in the Portugal’s construction industry in late 70s when VE incentive provisions were included in construction contracts. Thus, the Portugal’s system of VE was born out of a need to identify alternative approaches for satisfying the requirements of a project while lowering costs. However, VE in design is fairly new in the Portugal building industry. The objective of the current study is to obtain feedback from the design and project management organizations (both private and public) on the current use of VE in design, and to examine the VE practice in Portugal’s building industry by investigating theory and practice of VE in design. Thus, a survey was conducted in the last months of 1998 of the largest design and project management organizations in Portugal. This survey was completed with two building project case studies. This paper presents the findings of this survey.

## VALUE ENGINEERING IN DESIGN

A VE study during design phase attempts to identify unnecessary costs in design items and suggest design alternatives to reduce life-cycle costs without reducing the quality, function, and performance of a design (Acharya *et al.* 1995). Thus, multiple design alternatives are considered and most cost effective alternatives are selected on a continual basis throughout the design phase. However, only building projects with clear objectives can be value engineered to ensure cost-effectiveness (Mootanah 1998). Advocates of the VE analysis claim it is effective in reducing cost and improving the value of construction projects with clear objectives (Palmer *et al.* 1996; de la Garza and Alcantara 1997; Mootanah 1998). During the design phase, a VE study is a systematic method divided into several phases. An integral part of VE analysis is the *job plan*. There are several variations of this formal VE job plan (Value 91; Acharya *et al.* 1995; SAVE 1997; de la Garza and Alcantara 1997; McGeorge and Palmer 1997). In this paper, VE analysis refers to the study carried out during design phase.

## METHODOLOGY OF STUDY

The objectives of the research were met through an intensive literature review, a research survey and two case studies. The use of VE analysis was examined by

surveying 68 design and project management organizations operating in the Portugal's construction industry. These 68 organizations represent the largest design and project management organizations in the nation according to their annual turn-over. Thus, a research survey was conducted in the last months of 1998 covering those organization. In order to make an appraisal of VE practice two case studies were carried out. These case studies refer to building projects where VE analysis was used during design process. The data collected through the survey were enhanced if necessary through further contacts with the original respondent.

## **RESEARCH SURVEY**

The current research concentrate on two category of respondents: design and project management organizations operating in the building industry in Portugal. A questionnaire was designed and mailed to an equal number of designers and project managers; a total of 68 questionnaires were sent to the two parties. The reason to include project managers in the survey is because clients hire project management organizations to carry out on their behalf the VE analysis of the design.

The primary aim of the survey was to investigate the use of VE analysis in design, discover which system of VE is being implemented and which school of thought, if any, is the dominant one. The questions were based on the existing theory and schools of thought of how VE should be implemented. The questionnaire includes four parts. The first part includes question 1 which inquires whether VE analysis is used in the respondent projects. If VE analysis is not used, only part two is to be answered. If VE is used, parts three and four are to be answered. The second part includes questions 2 and 3 and inquires about the reasons why VE analysis is not used and whether there are any plans to use it in the near future. The third part includes questions 4 to 15. They are open-end questions regarding VE utilization i.e., the project types and project stages where VE study is carried out, the criteria used in selecting projects for VE analysis, extent of use of VE analysis, the length of time since VE has been formally instituted, the content of the agenda of VE studies, the entity responsible for carrying out the VE study, the method used for highlighting areas of poor value, the techniques used for generating, evaluating and developing design alternatives, and finally the cost of VE study. The fourth part includes question 16. Question 16 was intended to measure, on a subjective basis, the success of these organizations in implementing VE analysis. Respondents were asked to rate success in VE analysis implementation by indicating whether it is successful, somewhat successful, neither successful nor unsuccessful, somewhat unsuccessful, or unsuccessful. The responses are quantified into success rates by the author on a scale of 1 to 5, where 1 is unsuccessful and 5 is successful. Success indicators are calculated for each group of organizations. Success indicators also range between 1 and 5.

## **ANALYSIS OF RESULTS**

The research analysis is based on 32 positive responses, constituting a 47% response rate. This level of response is not unexpected considering that VE is a new management tool in design in Portugal. Some of the questionnaires were returned uncompleted by some organizations for various reasons, including lack of knowledge about VE, lack of time and resources, etc. Uncompleted questionnaires were not included in the analysis.

**Table 1:** Position held by the respondents

Position held	Category of respondents					
	Design		Project management		Total	
	No.	%	No.	%	No.	%
Director	4	20	2	17	6	19
Head of department	8	40	6	50	14	44
Manager	7	35	4	33	11	34
Partner	1	5			1	3
Adviser						
<b>Total</b>	<b>20</b>	<b>100</b>	<b>12</b>	<b>100</b>	<b>32</b>	<b>100</b>

**Table 2:** Experience of the respondents

Years of experience	Category of respondents					
	Design		Project management		Total	
	No.	%	No.	%	No.	%
0-5	1	5			1	3
6-10	5	25	4	33	9	28
11-15	9	45	5	42	14	44
16-20	4	20	1	8	5	16
21-25	1	5	2	17	3	9
Total	20	100	12	100	32	100

**Table 3:** Use of VE study in design

Use of VE	Category of respondents					
	Design		Project management		Total	
	No.	%	No.	%	No.	%
Organizations that use	9	45	10	83	19	59
Organizations that do not use	11	55	2	17	13	41
Total	20	100	12	100	32	100

### Characteristics of the respondents

Tables 1 and 2 respectively show the category and the position held by the respondents, and distribution of their experience. The majority of respondents held a position of seniority within their employer's organization.

A majority of the respondents within both groups of organizations are head of departments and project managers responsible for strategic projects, policy development, resources and production. The design organizations responding to the questionnaire included, private owned firms and public design units involved in the design process. Respondents from the project management group included, private owned firms and public bodies involved in project management tasks. Some of these project management organizations also provide design services. All are related to the building industry. In terms of the experience of the respondents, design organizations and project management organization have almost the same level of experience.

#### *Use of VE analysis in design*

Table 3 shows how respondents of both design organizations and project management organization answered to question 1.

The main reasons for not using VE study in their projects, for both organizations, are lack of standard or formal guidelines (46%), followed by "not required by their clients" (38%), and other reasons (16%). It was interesting to note that only one respondent indicated that VE has been used before, but that no distinguishable benefits had been obtained, and that it had not been used since then. It appears that

organizations that do not use VE study now, did not formally tried using VE before. Other reasons included the lack of funds for extra analysis, the lack of time, the unfamiliarity with VE study, and the specific nature of projects in some organization which are not worth the cost and time. Out of the respondents who indicated that their organization does not use VE study, only 23% indicated that they have specific plans to use VE study in future. The majority (77%) have no specific plans. Most of these respondents indicated that the reason why they do not use VE analysis is the lack of standard or formal guidelines.

#### *Project types*

The most common project type where VE analysis is used is for buildings (63%). This followed by water systems (14%). The next most common are sewer systems (11%). Economic development that includes roads, viaducts, development projects, gas systems and aviation (7%). The “other” types (5%) mentioned by respondents include HVAC systems and redevelopment areas.

#### *Criteria used in selecting for projects for VE analysis*

The potential for life-cycle cost savings is most commonly considered criterion by respondents in the selection of projects for VE analysis (53%). The second most common criterion is the importance of the project (27%). This is followed by the “useful life longer than” criterion (11%). The range of the useful life indicated is 10 to 50 years, with 20 years as the most common value. Finally, the least common criterion is the “initial cost greater than” alternative (5%). The range of initial costs used as minimum requirement for conducting VE analysis is 100,000 to 400,000 EUR (euro).

#### *Extent of use of VE*

Fifty three percent (53%) of the respondents clearly indicated the percentage of projects where VE is used (question 6) as a percentage of the EUR value of all projects, whereas 47% either indicated that this percentage is not known, or simply skipped this question. There is a variation in the range of projects where VE analysis is used. It is possible that most of the organizations (7 out of 9) that filled out the blank in the question use VE analysis either experimentally in a few projects (0 to 25% of all projects' EUR value) or have left this stage behind and use VE in almost all their projects (76-100% of all projects' dollar value). On the other hand, when examining the answers to question 14 “length of time VE analysis has been formally used” it is found that three out of the five respondents in the (26 to 50%) group have been using VE for six to ten years. Answers to question 7 indicate that nearly all organizations (95%) used VE study in new projects.

#### *Project stage*

Ninety percent (90%) of the respondents that used the VE analysis use it during design stage (question 8). The less common other two stages are the procurement stage (5%) and construction stage (5%). On the other hand, examining the answers to question 9 (design phase where VE study is carried out) it is found that sixty three (63%) of the respondents have been carrying out the VE analysis during the detailed design phase. Thirty seven percent (37%) of the respondents have been carrying out the VE study during the schematic design phase.

#### *Organization of the VE study*

Most of the respondents (90%) use the job plan divided into several phases for conducting the VE study with slight variations among them (question 10). There are several variations of the job plan. In most organizations (sixteen out of the nineteen respondents) the job plan involves: information gathering; function definition;

generation of design alternatives; evaluation of design alternatives; development of design alternatives; and presentation of VE proposals. Only 10% of the respondents use an informal approach for conducting the VE study of their projects. On the other hand, when examining the answers to question 11 (who is generally responsible for carrying out the VE study) it is found that in 58% of the respondents the VE is carried out by an external team. The remaining 42% use an “in-house” team for conducting the VE study.

The most commonly creative thinking technique that has been used is the brain storming. Nearly all respondents (95%) in the group belonging to organization that have been used the VE study use brain storming for formulating design alternatives of a current design (question 12). Eighty four percent (84%) of the respondents in the group belonging to organization that have been used the VE study indicated that the most commonly method used to evaluate design alternatives is the weighted matrix (question 13). Only, sixteen percent (16%) of the respondents use the voting system for evaluating design alternatives.

#### *Length of time VE has been used and its cost*

The analysis of results shows that VE study in design is rather new technique for 58% of the respondents in the group belonging to organization that have been used the VE study, since they started using it only in the last ten years (question 14). Thirty six percent (36%) of the respondents in this group had started using VE only in the last five years. However, 42% of respondents had been using VE for more than ten years, 25% of whom had used it for 20 years or more. When examining the results of question 16 (measure of success) it is found that all the respondents who had been using VE for more than ten years, with exception of one organization, considered VE study implementation in their organization as either successful or somewhat successful. Only 11% of the respondents in the group belonging to organization that have been used the VE study, were able to indicate the cost incurred in performing the VE study (question 15); furthermore, the values given by those respondents are vague. One of the responses is “less than 2%” and another is “approximately 5%”. The main apparent interpretation for this unmeasured cost and the poorly defined costs given by these organizations, could be derived from the fact that most VE studies are carried out by an external organization.

#### *Measure of success*

The majority of respondents (74%) in the group belonging to organization that used the VE analysis indicated that the success rate of using the VE analysis ranges between successful and somewhat successful. Only 16% of the respondents feel their organization is neither successful nor unsuccessful and 10% somewhat unsuccessful or unsuccessful. In further contacts with those organizations in the group that indicated a success rate of successful, they were asked how they measure the success of the VE study in their organizations. Majority of these respondents answered that they measure the success of VE study in terms of cost savings. Others answered that measure the VE analysis in terms of getting a better design.

## **CASE STUDIES**

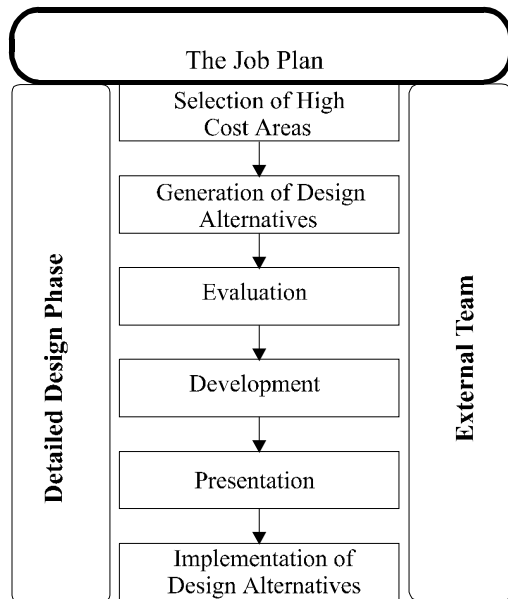
Two VE case studies were examined during this research. The striking items of cases examined were that: in one case the VE study was carried out around the job plan and on the schematic design, using an external team of consultants, and within the design organization environment; the other case the VE study was carried out also around the

job plan at construction phase, by the construction management contractor and on the design prepared by the design organization. In both cases the VE team selected areas of the design that, they found to be above average cost. Then guided by the function definition they looked for cheaper alternatives in these areas.

The first case study is drawn from the sport centre of “Alto da Faia” project in Lisbon, involving the Local Authority of the city of Lisbon and EPUL (Public Enterprise of Urbanization of Lisbon). “Alto da Faia” centre is a sport centre consisting of several sport and recreational areas. It comprises 3,500 m<sup>2</sup> of constructed areas over two floors and 7,000 m<sup>2</sup> of green areas. The second case is drawn from the Colombo Centre in Lisbon. Colombo Centre is a commercial complex consisting of retail, office and leisure areas. Its total construction area is approximately 400,000 m<sup>2</sup> over six floors.

In the first case study the VE team work was organized around the job plan and based on the existing drawings and specifications, and the original estimate. The job plan consisted of seven phases: information gathering; function definition; generation of design alternatives; evaluation; development; presentation; and implementation. During the information gathering phase, the VE team selected high cost areas of the design based on cost analysis of similar projects. Therefore, the VE team selected floor and wall finishes of the different areas of the sport centre for VE study, because they felt the initial costs of these areas to be above the average elemental costs of similar floor areas. For each area the function requirements were defined. Then, based on the defined functions the VE team, using the brain storming technique, generated a set of alternative systems for floors and walls meeting those functions. These alternative systems were later evaluated, both on economic and non-economic criteria. The purpose of this phase was to select the alternatives that have a high likelihood of providing cost savings and being implemented in the project’s design for further development. The VE team used the weighted matrix method together with a scoring system to evaluate each alternatives. Based on this evaluation a small number of alternative systems for each area were selected for further life cycle costing. Therefore, each wall and floor system was ranked according to its potential to save money. Next, the VE team prepared the VE report describing the proposed savings for each area of the sport centre in relation to the original estimate. The total proposed saving of the study was approximately 121,000 EUR, which meant 6% savings in relation to the original estimate of the project. The input of the client and the relationship of the VE and design teams appeared to make a significant contribution to the success of the VE study. The design team collaborated with the VE team in all phases of the job plan.

The Colombo project used a project delivery framework which combines construction management with design-build. Thus, the Colombo project was divided into 60 design-build packages of work. Design-build was chosen as the delivery method of the different parts of the project (work packages). In such arrangement the trade contractors were given a conceptual design of the work package put under bid. This process allowed the management contractor to apply the VE analysis during the evolution of the conceptual design to the detailed design. Therefore, several cost-effective VE proposals have surfaced and consequently implemented during the detailed design phase. The VE proposals were primarily for modifications in architectural and engineering systems. Significant changes were made in the architectural content engineering systems such as: external wall system, layouts and floor finishes; lighting systems; water supply system; and HVAC systems. These



**Figure 1:** Value engineering practice

changes resulted in a major impact on both the capital cost and the operation-and-maintenance cost for the project. The management contractor carried out the VE study as part of its management duties. The VE study was organized around the job plan and focused on high cost work packages.

## VALUE ENGINEERING PRACTICE IN PORTUGAL

Value Engineering practice represents what VE consultants actually do. The cases studies show that value engineering in Portugal is basically a design audit. It consists of a study structured loosely around the job plan divided into several phases (see Figure 1). It involves the selection of high cost areas of the design; generation of design alternatives; evaluation and development of design alternatives, presentation of value engineering proposals, and implementation). The VE study is carried out during design stage and less common during procurement and construction phases and using an external team.

The selection of high cost areas of the design is based n an elemental cost analysis. The VE team selected areas that, based on a elemental cost analysis of completed projects, they found to be above average cost. They then looked for cost saving alternatives in these areas. These cost saving alternatives were later evaluated (using the weighted matrix method) to select the VE proposals that have a high likelihood of providing cost savings. For each VE proposal, a detailed life-cycle cost analysis, including capital, operation and maintenance cost, was developed during the development phase. The most worth-cost effective VE proposals were presented to the owner for final approval and implementation.

The depth of analysis of the VE study was dependent on may factors that are not recognized as part of the VE theory. These factors include: the input of the client; the relationship among the participants (VE team, design team, and client); the design stage; the experience of the VE team; and the availability of elemental cost analysis of completed projects.



## CONCLUSION AND FUTURE RESEARCH

At the beginning of the present study, it was expected that design and project management organizations in Portugal would be using VE on a limited scale. This expectation was caused by the very few articles and papers encountered during the literature review. However, the survey showed that 51% of the respondents are using the VE analysis, either on a limited or an extensive scale. Some organizations have been using VE study for more than ten years.

Most of the respondents (74%) assessed their VE study utilization process as a successful or somewhat successful operation. This finding could be interpreted as a good indication that using VE study during design process is usually perceived as a successful process by organizations that use VE. In most organizations, VE analysis is used during one stage the design stage. From this study, it appears that VE in the Portugal construction industry is mainly a design audit. In most organizations the VE is study is structured around the job plan. Usually, the VE study is conducted by an external team. However, the input of the client and the relationship of the VE and design teams appears to contribute to the success of the VE study. Sixty two percent (60%) of the organizations that took part in the survey do not use the VE study. These organizations indicated that they need standard or formal guidelines for the VE study. Most of these organizations requested to be provided with the results of this study. Some of them may use VE analysis in the future and more systematically.

To gain a better understanding of VE study implementation currently in place in the construction industry, it is desirable to do the following: (1) Investigate the attitude and expectations of clients toward the Value Engineering in design; (2) Explore the possible relationships between VE and cost management; (3) Investigate the possible way for making VE work better and to be used more systematically ; and (4) Define major factors that are considered in measuring success in VE analysis. Future research should include more case studies where VE study was used.

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